
FINAL

Initial Feasibility Analysis Report

For Flood Control at Foxcroft Colony Condominiums and
Mosby Woods Condominiums, and Stream Restoration at Daniels Run

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Acronyms

BCA	Benefit/Cost Analysis
BFE	Base Flood Elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	FEMA Flood Insurance Study
FMA	Flood Mitigation Assistance
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program
IDF	Intensity Duration Frequency
If	Linear Feet
NFIP	National Flood Insurance Program
PDM	Pre-Disaster Mitigation
RFC	Repetitive Flood Claims
ROM	Rough Order of Magnitude
SRL	Severe Repetitive Loss
SWM	Stormwater Management
TP	Technical Paper
TR	Technical Release
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VDEM	Virginia Department of Emergency Management

Executive Summary

At the request of the City of Fairfax, Department of Public Works (under Purchase Order 130682), an initial feasibility analysis for flood control at the Foxcroft Colony Condominiums and the Mosby Woods Condominiums and for stream restoration at Daniels Run was conducted by URS Corporation with Wetlands Studies and Solutions, Inc. The purpose of this initial feasibility analysis was twofold: (1) to investigate flood risks at both condominium sites and to determine the causes of stream erosion at Daniels Run near the Daniels Run Elementary School; and (2) to identify measures for reducing the flooding and stream erosion in these areas. This analysis is considered the first step in developing flood-risk management plans and measures for addressing stream erosion.

Current Conditions

The Foxcroft Colony Unit Owners Association and the Mosby Woods Homeowners Association have petitioned the City of Fairfax (also referred to as “the City”) to address flooding risks in their communities. Portions of both condominium communities are located within the Federal Emergency Management Agency (FEMA) 100-year floodplain and have experienced significant flooding in the past several years. Both communities were built in the 1960s before the first FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) were prepared delineating the 1% annual chance floodplain (100-year floodplain).

Significant flooding at the Foxcroft Colony Condominiums occurred on September 6, 2008 and again on September 8, 2011 when 12 units were flooded to a depth of 10 inches. The effects of Hurricane Sandy on October 26, 2012 were seen at the Foxcroft Colony property grounds; however, the units were spared from flooding due to significant flood-fighting activities such as placing sand bags at the buildings’ entrance points. Based on the City’s FIRMs, there are 28 condominium units in 7 buildings at the complex that are located in the 100-year floodplain and are at risk of future flooding. Several commercial properties in the vicinity of the Foxcroft Colony Condominium complex are also located within the floodplain and affected during large storm events.

The Mosby Woods Condominiums have experienced severe flooding over the past seven years during three major storm events. The first storm event reported by residents to cause flooding at Mosby Woods was an unnamed tropical cyclone that hit Virginia on June 25th and 26th, 2006. Tropical Storm Lee caused major flooding on September 8, 2011 inundating 7 units with several inches of water; and the most recent storm event impacting this community was Hurricane Sandy in October 2012. As shown on the FIRM for the City, there are 7 buildings including 28 first-floor units at the Mosby Woods Condominiums located within the 100-year floodplain.

The portion of the Daniels Run channel, that is the subject of this study, is located on the property of Daniels Run Elementary School (owned by the City School Board). Stream erosion is apparent at this section of the stream in spite of past attempts to resolve erosion issues. As part of a restoration effort in July 2005, Filtrex® Bank Stabilization Soxx™ was installed along both sides of the channel adjacent to the school property. This effort proved to be unsuccessful, probably because vegetation, necessary to anchor the system, never grew due to the shade from larger trees along the bank prohibiting new vegetative growth.

Recommendations for Improvements

The recommended measure for each site is dependent on the planning objectives and constraints of the study area. Various plans were evaluated that reduced the flood risk for more frequent storm events (e.g., 25-year, 10-year, 1-year) to plans that reduced the flood risk for the 100-year flood event. Because criteria for the frequency storm for design were not specified, this analysis evaluated and chose alternative plans that were the most cost-effective and reduced flood risk. For Daniels Run, various alternatives were evaluated to restore the reach and to minimize future stream erosion.

Three alternative plans are recommended for the Foxcroft Colony Condominiums which vary in cost and risk mitigation. Alternative Plan 1 is to flood-proof the buildings with an estimated cost of about \$130,000. While this alternative plan may not provide the highest flood-risk reduction when compared to other plans evaluated in this analysis, it appears to be the more cost effective plan due to the high costs associated with the other plans. Alternative Plan 2 consists of minor localized drainage improvements to increase the conveyance of flow on the Accotink Creek including dredging a portion of the creek and a device backflow prevention device to prevent floodwater from the Accotink Creek floodplain at the Foxcroft Colony community. Rough order of magnitude costs for this alternative are \$726,000. The third option (Alternative Plan 3) is to install a floodwall along Old Pickett Road and a portion of Pickett Road to block floodwaters from entering Foxcroft Colony grounds. A pump station is necessary to remove any interior drainage collected behind the floodwall. Estimated costs for the floodwall and pump station are approximately \$3 million. Alternative Plan 3 would provide the highest degree of flood risk reduction, protecting the community from the 100-year flood.

For Mosby Woods Condominiums two alternative plans are recommend in this study. The first plan is to flood-proof the condominium buildings located within the 100-year floodplain. Flood-proofing costs are estimated to be \$125,000. The same advantages and disadvantages apply to this plan as with flood-proofing the Foxcroft Colony buildings. The main disadvantage is that human intervention is required to set up the flood barriers prior to a flood event. However, if implemented correctly, this plan will reduce the flood risk to Mosby Woods residents located in the floodplain. It should be noted that flood-proofed residents in the floodplain at both Foxcroft Colony and Mosby Woods should continue to purchase flood insurance since flood-proofing is not a FEMA recognized method to remove buildings from the floodplain. Proposed Alternative Plan 2 for Mosby Woods includes installing an earthen levee / berm along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive and includes a pump station to remove drainage behind the levee. Estimated costs for this alternative plan are approximately \$2.7 million. This plan provides a higher level of flood risk reduction compared to flood-proofing the buildings.

Several measures were analyzed to address the stream erosion on Daniels Run at Daniels Run Elementary School and two design concepts were developed on a conceptual design level. The recommended solution is Alternative Plan 2, which entails grading the channel banks to achieve larger cross-sections and a small floodplain bench; this would likely result in the most stable, environmentally-beneficial, and aesthetically-pleasing restoration. A rough range of expected costs to restore approximately 750 linear feet (lf) of Daniels Run on the school property is \$400-\$600 per lf. This equates to a ROM cost of \$300,000 to \$450,000 and would result in a permanent restoration of Daniels Run.

1 Introduction

This analysis was requested by the City of Fairfax to investigate flood risks at the Foxcroft Colony Condominiums and at the Mosby Woods Condominiums, and to determine the causes of stream erosion at Daniels Run near the Daniels Run Elementary School. This *Initial Feasibility Analysis Report for Flood Control at Foxcroft Colony Condominiums and Mosby Woods Condominiums, and Stream Restoration at Daniels Run* documents a set of issues found at each study area and associated findings to reduce flooding and stream erosion risks.

As shown in the Location Map (**Figure 1-1**), the Mosby Woods Condominium community is approximately three miles west of Interstate 495, the Capital Beltway, near the intersection of Route 29 Fairfax Boulevard and Route 123 Chain Bridge Road. The Foxcroft Colony Condominium community is located approximately one mile to the east of Mosby Woods, at the intersection of Route 50 and Pickett Road. The study area of Daniels Run stream is located near the Daniels Run Elementary School, near the intersection of Old Lee Highway and Farrcroft Road.

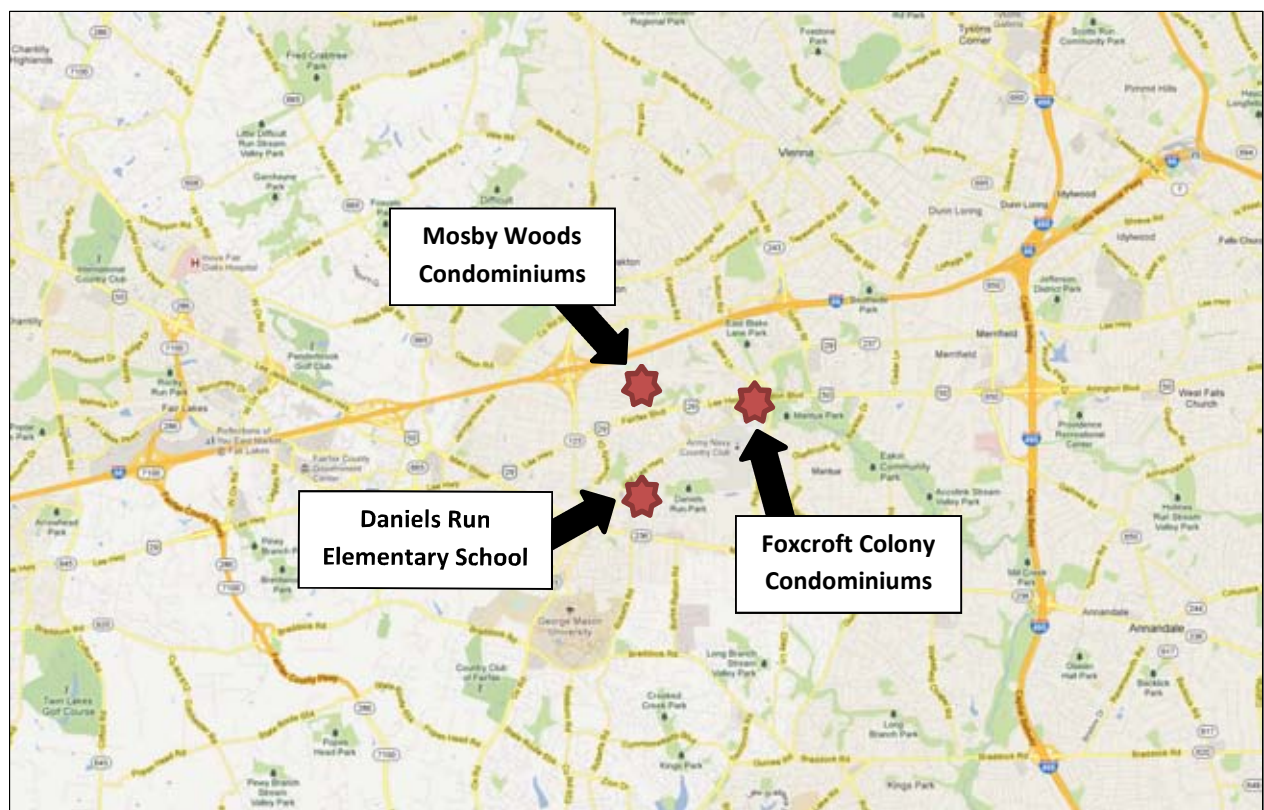


Figure 1-1. Location Map

1.1 Study Authority

The City of Fairfax authorized this Initial Feasibility Analysis Report to evaluate flooding issues at the Foxcroft Colony Condominiums and at the Mosby Woods Condominiums, and to evaluate stream erosion on Daniels Run through Purchase Order No. 130682, dated January 2, 2013.

1.2 Purpose and Scope

The purpose of this initial feasibility analysis was twofold: (1) to investigate flood risks at both condominium sites and to determine the causes of stream erosion at Daniels Run near the Daniels Run Elementary School; and (2) to identify measures for reducing the flooding and stream erosion in these areas. This analysis is considered the first step in developing flood-risk management plans that could be implemented at the Foxcroft Colony Condominiums and at the Mosby Woods Condominiums, and measures for addressing stream erosion on Daniels Run.

This analysis identifies potential alternatives and conceptional design plans to reduce risks associated with flooding and stream erosion. The study scope consists of:

- Documenting the flooding problems at the Foxcroft Colony Condominiums and the Mosby Woods Condominiums.
- Documenting the causes of stream erosion on Daniels Run near the Daniels Run Elementary School.
- Evaluating and proposing alternative plans at the Foxcroft Colony Condominiums and at the Mosby Woods Condominiums as part of an alternatives analysis to address flooding issues.
- Evaluating and proposing alternative plans as part of an alternatives analysis to address stream erosion on Daniels Run.
- Providing conceptual designs of the proposed plans and evaluating each plan using criteria outlined in this analysis.
- Documenting associated findings in this initial feasibility analysis report.

1.3 Plan Objectives

The plan objectives for the Foxcroft Colony Condominiums and the Mosby Woods Condominiums are to identify the flood risks and flood damages, and to evaluate measures for flood protection and are specified as follows:

- To reduce flood risk and flood damages to the residents of Foxcroft Colony and Mosby Woods.
- To provide additional flood risk management features to ensure that flood waters are contained within a designed area.
- To reduce the adverse effects of flooding on transportation delays to critical transportation corridors including, but not limited to, the intersection of Pickett Road and Old Pickett Road near the Foxcroft Colony Condominiums.
- To restore or improve degraded riverine and riparian habitat in and along the North Fork Accotink Creek in the vicinity of Mosby Woods Condominiums.

To address stream erosion on Daniels Run, the plan objectives are:

- To return long-term stability to the degraded stream on the school property in a manner that will not only enable the channel to withstand the extreme hydraulic environment found in this confined urban channel, but one that also provides a diverse, healthy, and sustainable riparian ecosystem.
- To prevent the loss of additional land and to protect adjacent infrastructure (e.g., fences, trails, utilities).
- To provide a significant learning opportunity for students and staff at the school.
- To enable students and the public to access the stream in a much safer manner than currently exists. This is especially important given the location of the channel on school property.

1.4 Planning Constraints

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified for the Foxcroft Colony Condominiums and the Mosby Woods Condominiums are as follows:

- Avoid increasing peak Accotink Creek flood stages, either upstream or downstream.
- Avoid negatively impacting natural features in the vicinity of the study area.
- Minimize the loss of floodplain in accordance with Section 110-57(c) of the City Code.
- Comply with all Federal, State and local regulations.
- Consider future development within the watershed and the floodplain in the design of any flood reduction measure in the Accotink Creek.
- Consider the available funding.

For the Daniels Run study area planning constraints are as follows:

- Minimize tree loss.
- Avoid impacts to the adjacent infrastructure (trails, fences, and utilities).
- Avoid impacting the school infiltration project.
- Consider that extreme hydrologic environment will limit restoration options.
- Restore a relatively short portion of an existing incised channel to limit the available restoration options.
- Avoid impacts to the 100-yr water surface elevation (FEMA Floodplain).
- Consider the access and close proximity to the school that will necessitate the need to coordinate restoration work with school activities.
- Consider the available funding.

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2 Study Process and Considerations

As part of this analysis, available engineering, economic and environmental data were collected. Public stakeholders and potentially affected landowners were identified. Potential issues and opportunities were defined. The sections below provide details about the process and the considerations which took place as part of this analysis.

2.1 Stakeholder Meetings

Stakeholder meetings were held with the Foxcroft Colony Unit Owners Association, the Mosby Woods Community Association, and with the Daniels Run Elementary School for each study site. The intent of these meetings was to provide the stakeholders with information about the City's undertaking of this analysis and to provide stakeholders with an opportunity to express their thoughts and comments. A number of public concerns were identified during these meetings. For the Foxcroft Colony and the Mosby Woods residents, the biggest concern is the potential for reoccurring flood damage to several of their first floor units and community grounds. For the Daniels Run Elementary School, one of the biggest concerns was directed to the extents of restoration efforts necessary to address the erosion issue and the possibility that the restoration will affect the existing natural vegetation and plantings along the Daniels Run in the vicinity of and on the school grounds.

The dates of the stakeholder meetings are presented in **Table 2-1** below. The meeting agendas and meeting minutes taken for each of these stakeholder meetings can be found in **Appendix B**.

Table 2-1: Stakeholder Meetings

Study Area	Meeting Location	Date	Attendees ¹
Foxcroft Colony	Onsite Management Office - 9483-A Fairfax Boulevard	February 7, 2013 7:00 PM	Members of the Foxcroft Colony Unit Owners Association, Foxcroft Colony Site Manager, Legum & Norman Managing Agency, City of Fairfax, URS Corporation
Mosby Woods	Mosby Woods Onsite Office - 10170 Mosby Woods Drive	February 5, 2013 7:00 PM	Members of the Mosby Woods Board of Directors, TWC Association Management, City of Fairfax, URS Corporation
Daniels Run	Daniels Run Elementary School	February 26, 2013 10:00 AM	Daniels Run Elementary School representatives, City of Fairfax, URS Corporation, WSSI

¹Refer to the Sign-In Sheets provided in **Appendix B** for the names and the organization of the individuals attending the meeting.

2.2 Prior Reports and Relevant Information

The following reports and technical documents reviewed for each study area were either provided by the City of Fairfax or were publically available:

- City of Fairfax, Virginia Watershed Management Plan – Final Report, dated July 2005 prepared by the Louis Berger Group, Inc. and Gannett Fleming, Inc.
- Flood Insurance Study. City of Fairfax, Virginia (Independent City). Study Number 515524V000B. Federal Emergency Management Agency. June 2, 2006.
- USACE HEC-HMS Hydrology Model prepared by Dewberry & Davis for the City of Fairfax, Department of Community Development and Planning, undated.
- USACE HEC-RAS Hydraulics for Model the City of Fairfax Flood Study, prepared by Dewberry & Davis for the City of Fairfax, Department of Community Development and Planning, dated December 1998.
- GIS information provided by the City of Fairfax.
- Proposed Bridge Plan, Route 237 over Accotink Creek – City of Fairfax, prepared by Commonwealth of Virginia, Department of Highways and Transportation dated 1975.
- Proposed Bridge on Pickett Road over Accotink Creek Plan prepared by the Commonwealth of Virginia, Department of Highways and Transportation, dated 1981, revised 1982.
- Accotink Creek Watershed Management Plan, prepared by the Fairfax County Department of Public Works, dated January 2011.
- Daniels Run Stream Restoration, Fairfax, Virginia: 30 Percent Conceptual Design Report. Report # CBFO-S06-05. U.S. Fish and Wildlife Service. August 2006.
- Daniels Run Stream Restoration, Fairfax, Virginia: Floodplain Analysis Report. Report # CBFO-S07-01. U.S. Fish and Wildlife Service. March 2007.
- Stream Corridor Restoration. Principles, Processes, and Practices. Federal Interagency Stream Restoration Working Group. October 1988.

In addition to the above documents, the following information provided by the Foxcroft Colony Unit Owners Association was reviewed:

- Pictures documenting the 2008 and 2011 flood events and various typical storm events.
- Flood Insurance Claim from September 8, 2011 flood event prepared by Sweet Claim Services, Inc. dated December 26, 2011.
- Structural Damage Claim Policy prepared by State Farm Insurance, dated October 6, 2008 for September 6, 2008 flood event.
- Map of condominium complex with buildings affected by September 2011 Tropical Storm Lee flood event highlighted.
- Letter prepared by Foxcroft Colony Condominiums Unit Owners Association to Honorable Robert F. Lederer, Mayor regarding the Proposed Capital Improvement Program Budget, FY2013 to FY2017, dated April 10, 2012.
- News Article “Hanna Pummels Region” in Fairfax Connection, dated September 08, 2008 by Michael O’Connell.

2.3 Evaluation Criteria for Flood Control Projects

A cursory technical analysis of all proposed measures was performed, and screening criteria to focus evaluation and design efforts was evaluated for the most implementable alternatives at each study site. The screening criteria represent the most critical factors to be considered in selecting plans for further evaluation. These criteria include effectiveness, environmental considerations, stakeholder impacts, and cost effectiveness. The criteria were used to evaluate the overall characteristics of each alternative measure and to identify those most likely to meet the proposed project purpose and objectives at each of the three study areas. The criteria used to rate each alternative measure is further described in the proceeding sections.

2.3.1 Effectiveness

Effectiveness is gauged as the ability of the alternative plan to achieve its goal(s). For the Foxcroft Colony Condominiums and the Mosby Woods Condominiums, effectiveness means reducing flood levels and flood risks at these properties; and for Daniels Run, effectiveness means reducing stream erosion and restoring the channel. Effectiveness is evaluated in terms of what recurrence interval the measure protects against or the number of structures the measure provides protection for. Effectiveness is related to implementability and risk; however, to evaluate a proposed measure for this analysis, it is assumed the project is implementable or constructible without significant determinants or issues. It is also assumed that risk can be managed at an acceptable level. The vulnerability of the measure failing is considered to be low. Risk associated with a measure includes the uncertainties, vulnerabilities and potential consequences.

2.3.2 Environmental Considerations and Permitting

A review of environmental considerations was conducted for the proposed alternative plans at each study area. Each project was evaluated for the effects of natural resources, and impacts were predicted based on this preliminary analysis and conceptional design. The predicted impacts of each alternative, including consequences on relevant environmental resources, are described. Additional information is provided in **Appendix D** providing details on permit requirements that may potentially affect an alternative plan proposed in this analysis.

2.3.3 Stakeholder Impacts

Impacts to the stakeholders in the study area were evaluated. To a lesser degree, potential controversy and general acceptance of the stakeholders for a proposed measure were identified. This is based on information gathered and opinions shared during stakeholder meetings held with the study area stakeholder group described previously.

2.3.4 Cost Effectiveness

A component of the relative cost is to include a determination of cost-effectiveness. There are two different methods for assessing cost-effectiveness: (1) a quick screening to initially access whether the project is likely to be cost-effective, and (2) performing a Benefit/Cost Analysis (BCA). As part of this analysis, the first method, screening, was performed on each alternative plan proposed due to time and financial constraints associated with this study. However, it should be noted that to obtain any Federal

or State project funding, a BCA using FEMA-approved methodologies may be necessary. Additional information regarding a BCA is described in Section 2.5, Grant and Funding Opportunities.

Table D-1 (shown here on the right), taken from FEMA Publication (FEMA 551) *Selecting Appropriate Mitigation Measures for Flood Prone Structures*, provides a screening matrix for determining cost-effectiveness of a project. The attributes included in this table are the frequency of a flood, the level of damage, the project cost, and the project benefits. For example, if the frequency of a flooding is a 10-year flood, the project will have a very high likelihood of cost-effectiveness if the cost is low.

Table D-1. Quick Screening to Determine the Likelihood of Cost-Effectiveness

Attribute	Likelihood of Cost-Effectiveness			
	Very High	High	Moderate	Low
Frequency of Flood	10-year flood	10- to 25-year flood	25- to 50-year flood	50- to 100-year flood
Level of Damage	Very high damage	High damage	Limited damage	Minor damage
Project Cost	Low relative to damages	Moderately-low relative to damages	Close to cost of damages in frequent floods	High relative to damages in frequent floods
Project Benefits	Very high	High	Moderate	Low
Criticality (impact or loss of function)	Very high, broad damages to community	High damages to key facility; community	Moderate loss of certain functions; limited impact	Little or no loss of functions; minor impact

(Source: How to Determine Cost-Effectiveness of Hazard Mitigation Projects, Chapter 3 from FEMA's Mitigation BCA Toolkit Version 2.0)

Based on the combination of the estimated cost of the project and the likelihood of effectiveness and mitigation of risk, a level of cost-effectiveness was assigned for each plan.

2.4 Rough Order of Magnitude Costs

Relative costs, associated with a proposed alternative measure or plan, are provided in this analysis. Based on the level of detail for each of the proposed plans, relative costs have a rough order of magnitude costs based on costing information obtained from various sources including the following publications and databases:

- FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding*
- FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*
- RSMeans Cost Data Online

It should be noted that relative costs associated with the alternative plans are provided in rough order of magnitude. Based on the limited scope of this analysis and level of conceptual design, the project costs provided may vary considerably depending on design elements not reviewed as part of this study.

2.5 Grant and Funding Opportunities

2.5.1 Federal Grants and Funding

FEMA offers hazard mitigation assistance programs that all have unique statutory authorities, program requirements, and triggers for funding. These programs have the common goal of providing funding to States, Territories, Tribal governments, and local communities to reduce the loss of life and property from future natural hazard events.

FEMA administers the following Hazard Mitigation Assistance (HMA) grant programs:

- Hazard Mitigation Grant Program (HMGP)
- Pre-Disaster Mitigation (PDM)
- Flood Mitigation Assistance (FMA)
- Repetitive Flood Claims (RFC)
- Severe Repetitive Loss (SRL)



Currently, funds are only available under the HMGP, the PDM, and the FMA programs because the SRL and the RFC programs have been folded into FMA.

Hazard Mitigation Grant Program (HMGP): The HMGP assists in implementing long-term hazard mitigation measures following Presidential Disaster Declarations by providing grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The total amount of HMGP funding is based on the estimated total Federal assistance provided by FEMA for disaster recovery under the Presidential Disaster Declaration.

- Up to 7% of the Grantee's HMGP ceiling may be used for mitigation planning activities in compliance with 44 CFR Section 201.3(c)(4).
- Up to 5% of the Grantee's HMGP ceiling may be used for mitigation measures that are difficult to evaluate against traditional program cost-effectiveness criteria (i.e., the 5% initiative).

Pre-Disaster Mitigation (PDM): The PDM provides funds on an annual basis for hazard mitigation planning and for the implementation of mitigation projects prior to a disaster. The goal of the PDM program is to reduce the overall risk to the population and structures, while at the same time, also reducing reliance on Federal funding from actual disaster declarations.

Flood Mitigation Assistance (FMA): The FMA provides funds on an annual basis so that measures can be taken to reduce or eliminate the risk of flood damage to buildings insured under the National Flood Insurance Program (NFIP).

The chart presented in **Appendix E** illustrates the similarities and differences among the grant programs described above. Additional details are provided in subsequent sections related to potential FEMA grant and federal funding opportunities for each of the proposed flood control alternative plans.

In addition to HMA grants, Disaster Survivor Assistance funds are available to local communities to support direct disaster relief efforts for past events that are declared as a major disaster. To qualify for assistance, losses must have occurred in an area covered by a disaster declaration. Disaster declarations

are typically declared by individual States or Territories for specific disaster events. FEMA collects data on major disaster declarations throughout the country which can be accessed at the FEMA website. HMGP is open for 12 months from the date of the Disaster Declaration. The only major disaster declaration reported in Virginia that is still actively accepting applications from sub-applicants for disaster mitigation as of the date of this analysis is DR-4092 for Virginia Hurricane Sandy.

2.5.2 State Grants and Funding

The Virginia Department of Emergency Management runs the Unified Hazard Mitigation Assistance (HMA) Grant Program 2012. Grants are awarded through four yearly grant programs and one disaster funded grant program. The HMA program is subject to the availability of federal appropriation funding or Presidential Disaster Declaration. The purpose of this program is to support state and local hazard mitigation structural and planning projects.

All localities must have a FEMA-approved hazard mitigation plan prior to application. Projects funded by the Virginia Department of Emergency Management (VDEM) HMA must conform to the State Hazard Mitigation Plan; must conform to environmental, historical, and economic justice issues; must provide a long-term solution for the community; must demonstrate cost-effectiveness; must comply with program regulations, and must be consistent with the State and local government's overall mitigation strategies as listed in their all-hazard mitigation plan.

The City of Fairfax is part of, and covered under, the Northern Virginia Regional Hazard Mitigation Plan.

2.6 Significant Recent Storm Events

Rainfall data for rainfall events known to affect the Foxcroft Colony Condominiums and the Mosby Woods Condominiums were acquired from local rain gauges. The Foxcroft Colony Condominiums experienced significant flooding due to Hurricane Sandy in 2012, Tropical Storm Lee in 2011, and Hurricane Hanna in 2008. The Mosby Woods Condominiums experienced significant flooding due to Hurricane Sandy in 2012, Tropical Storm Lee in 2011, and an unnamed tropical cyclone in 2006.

Data from Rain Gauge KVAFAIRF12 (see **Figure 2-1**) were acquired from Hurricane Sandy and Hurricane Lee. For Hurricane Hanna, the nearest rain gauge with data from 2008 was KVAFAIRF7, located approximately four miles southwest of the Foxcroft Colony community at Kings Park West (see **Figure 2-2**). For the storm in 2006, the nearest rain gauge with data from 2006 was KVAFAIR12, located at Ronald Reagan Washington National Airport (see **Figure 2-3**).

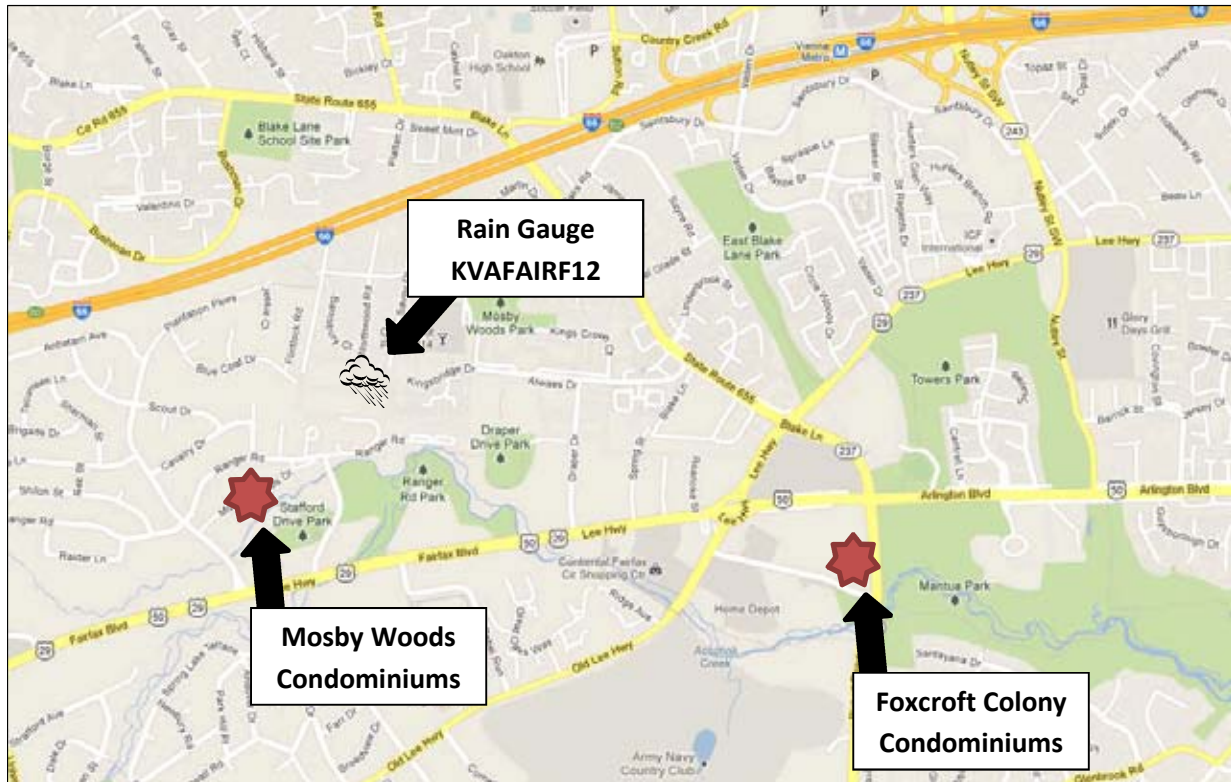


Figure 2-1. KVAFAIRF12 Rain Gauge Location

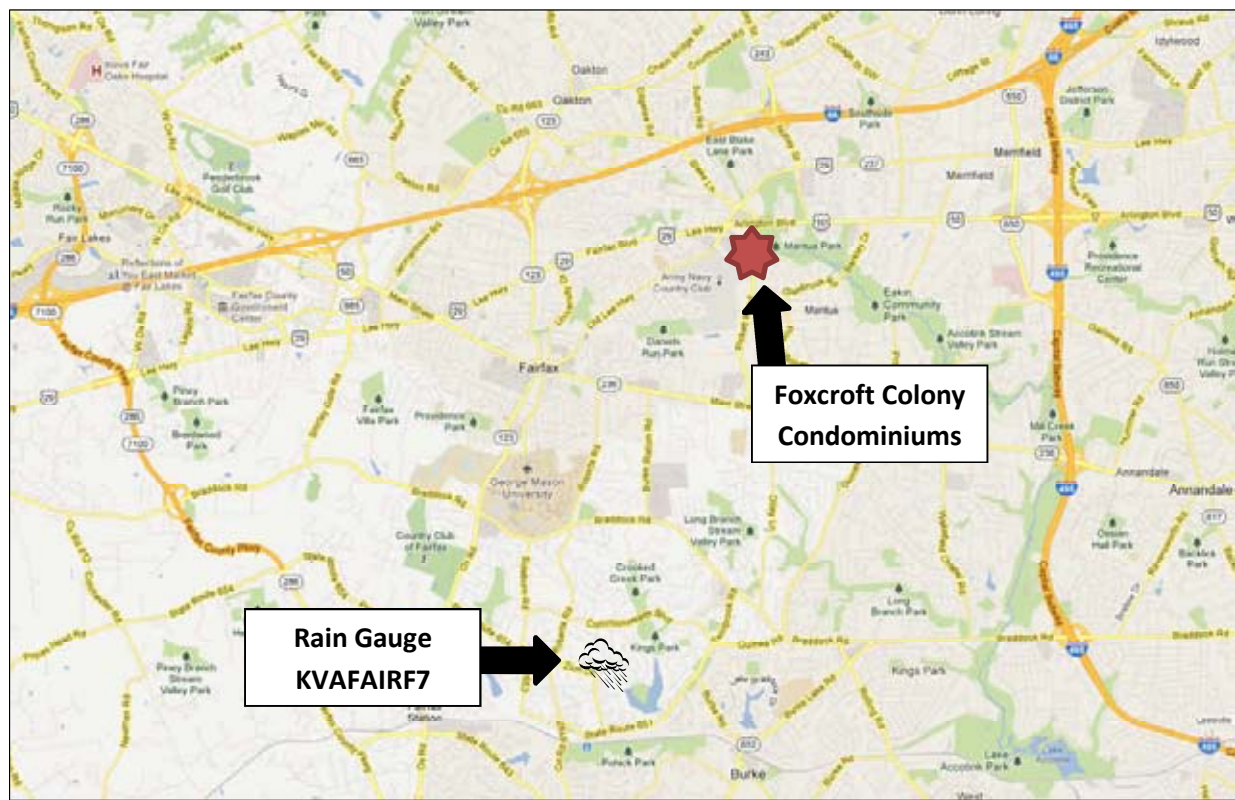


Figure 2-2. KVAFAIRF7 Rain Gauge Location

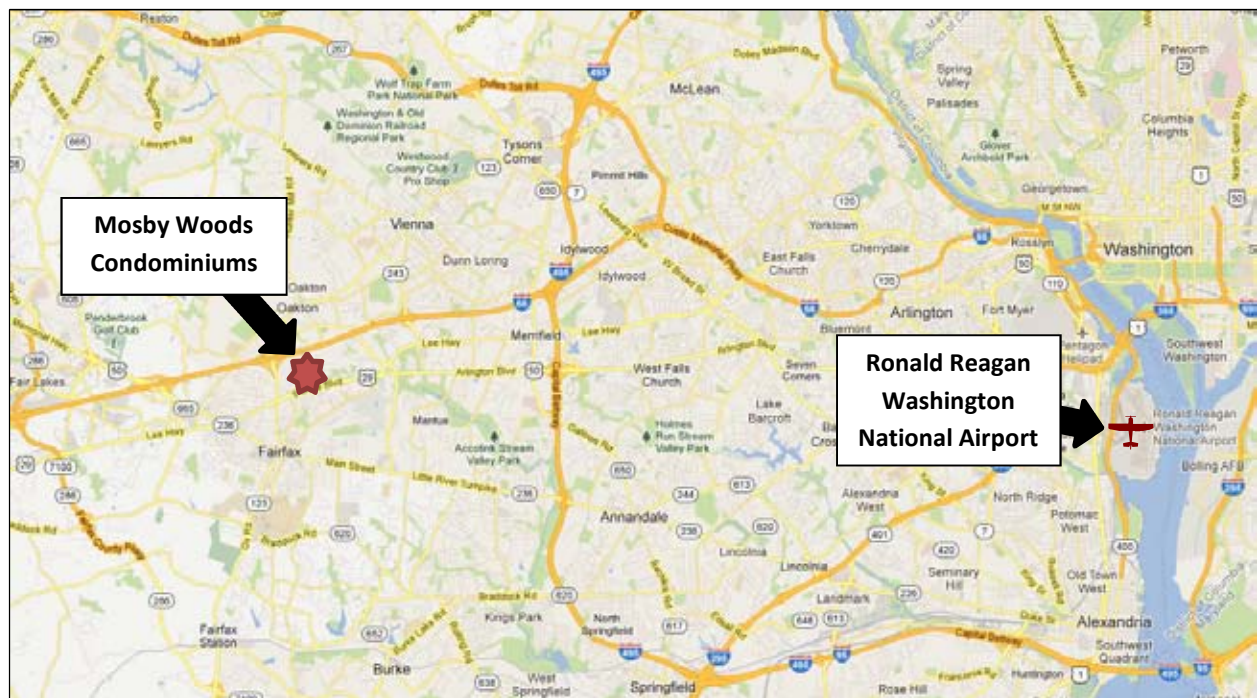


Figure 2-3. Ronald Reagan Washington National Airport Rain Gauge Location

Total rainfall and storm duration for each storm are shown in **Table 2-2**. The duration of each storm was determined based on the time when rainfall began to fall continuously until it ended. The total rainfall is the amount of rain that fell during that time. From the reported rainfall data, charts were developed showing the rate of rainfall (inches) versus time (available in **Appendix F**).

Table 2-2: Rainfall Event Summary Table

Rainfall Event	Date	Total Rainfall	Full Duration
Hurricane Sandy	October 29, 2012	6.5 inches	48 hours
Tropical Storm Lee	September 7-8, 2011	11.0 inches	82 hours
Hurricane Hanna	September 6, 2008	6.65 inches	13 hours
Unnamed Tropical Cyclone	June 25-26, 2006	5.7 inches	23 hours

The 6-hour, 12-hour, and 24-hour peak durations for Hurricane Sandy, Tropical Storm Lee, Hurricane Hanna and the 2006 unnamed tropical cyclone are shown in **Table 2-3**. The 6-hour storm was ascertained by determining the amount of rain that fell during the most intense six hours of the storm. The 12-, 24-, and 48-hour storms were determined using a similar method.

Table 2-3: Rainfall Event Peak Intensity – Duration Estimates

Rainfall Event	6-hr (inches)	12-hr (inches)	24-hr (inches)	48-hr (inches)
Hurricane Sandy	1.8	3.2	5.3	6.5
Tropical Storm Lee	5.3	6.5	7.7	9.1
Hurricane Hanna	5.35	6.61	6.65	6.65
Unnamed Tropical Cyclone	3.3	4.5	5.7	5.7

Table 2-4 provides the 1-year, 2-year, 10-year, 25-year, 50-year, 100-year, and 500-year storm events based on NOAA Atlas 14 precipitation estimates for Vienna, Virginia. These events have a 100-, 50-, 10-, 4-, 2-, 1-, and 0.2 change, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average periods between events of a specific magnitude, rate floods occur at short intervals or even within the same year.

Table 2-4: NOAA Atlas 14 Precipitation Frequency Estimates

Recurrence Interval (Frequency)	Duration			
	6-hr (inches)	12-hr (inches)	24-hr (inches)	48-hr (inches)
1-year	1.88	2.28	2.63	3.04
2-year	2.28	2.76	3.18	3.68
10-year	3.36	4.12	4.87	5.59
25-year	4.08	5.08	6.09	6.93
50-year	4.70	5.92	7.18	8.09
100-year	5.37	6.85	8.41	9.39
200-year	6.10	7.89	9.82	10.8
500-year	7.18	9.49	12.0	13.0

¹ Based on NOAA Atlas 14 point precipitation estimates for Vienna, Virginia.

It can be inferred when comparing the rainfall events of Hurricane Sandy, Tropical Storm Lee and Hurricane Hanna to recurrence intervals in NOAA Atlas 14 for Vienna, Virginia that each of these events are record storms (refer to **Table 2-5**). Based on these results, it is estimated that Hurricane Sandy is between a 10-year and 25-year, 24-hour event. Tropical Storm Lee and Hurricane Hanna both most closely resemble a 100-year, 12-hour event. However, due to the long duration of Tropical Storm Lee, this event may also fit a 100-year, 48-hour duration event. The 2006 unnamed tropical cyclone is between a 10-year and 25-year, 24-hour storm event.

Table 2-5: Estimated Frequencies for Known Flooding Events

Recurrence Interval (Frequency)	Duration			
	6-hr (inches)	12-hr (inches)	24-hr (inches)	48-hr (inches)
1-year	1.88	2.28	2.63	3.04
2-year	2.28	2.76	3.18	3.68
10-year	3.36	4.12	4.87	5.59
Hurricane Sandy			5.3	
Unnamed Tropical Cyclone		4.5	5.7	
25-year	4.08	5.08	6.09	6.93
50-year	4.70	5.92	7.18	8.09
Tropical Storm Lee		6.5		9.1
Hurricane Hanna		6.61		
100-year	5.37	6.85	8.41	9.39
200-year	6.10	7.89	9.82	10.8
500-year	7.18	9.49	12.0	13.0

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3 Foxcroft Colony Condominiums

There is a high risk of flood damage to the Foxcroft Colony Condominiums and other nearby properties along the Accotink Creek. Flooding also causes damages to the urban infrastructure and disrupts transportation at the intersection of Pickett Road and Old Pickett Road as well as access to properties in this area. The following sections provide information describing the study area location, identifies representative stakeholders, and provides a description on the history of the flooding issues at Foxcroft Colony Condominiums.

3.1 Location of the Study Area

The Foxcroft Colony Condominiums are located in Fairfax City, Virginia approximately two miles west of 495, the Capital Beltway at the intersection of Route 50 and Pickett Road bound by Old Pickett Road to the south. Accotink Creek is located approximately 300 feet south of the condominiums, and Gateway Regional Park is located between the creek and the condominiums (see **Figure 3-1**).

An earthen berm borders the Accotink Creek for almost the entire length of the park, except in one area where there is a drainage ditch. The drainage ditch is designed to convey stormwater runoff from the southeast corner of the Foxcroft property to Accotink Creek; however, the ditch does not appear to have sufficient grade to adequately convey water to the creek, as evidenced by standing water in the ditch and cattails observed near the culvert (refer to **Figure 3-2**). For additional photographs of this study area taken at time of field investigation on January 23, 2013, refer to **Appendix C**.

3.2 Stakeholders

There are many stakeholders associated with this study area in addition to the Foxcroft Colony residents since many flood control projects could affect the floodplain and elevation of floods in the vicinity of the Foxcroft Colony community. The following have direct involvement at the Foxcroft Colony Condominiums study area:

- City of Fairfax
- Foxcroft Colony Condominiums Residents and the Foxcroft Colony Unity Owners Association
- Legum and Norman Management Agent
- Nearby property owners including American Craftsmen Pool and Spa; Oskuie Service Center; and Student Van Lanes
- Gateway Regional Park, Fairfax County Park Authority

3.3 History of Flooding

Over the past five years, there have been three rainfall events that have caused flooding at the Foxcroft Colony Condominiums. Other storm events have also caused flooding on property grounds. This study will be limited to the three events that caused the most significant recent flooding which affected habitable structures.



Figure 3-1. Vicinity Map of Foxcroft Colony Condominiums



Figure 3-2. Photographs of Culvert System and Drainage Ditch Connecting to Accotink Creek

The most recent rainfall event was Hurricane Sandy on October 26, 2012. A year prior, Tropical Storm Lee caused major flooding on September 8, 2011 where 12 of the 312 condominium units, as well as the common area of five buildings, were flooded with over 10 inches of water. Refer to **Figure 3-3** indicating buildings at Foxcroft Colony that have experienced flooding during the 2011 flooding event.



Figure 3-3. Buildings Affected by Historical Flooding at the Foxcroft Colony Condominiums

Photographs showing evidence of flooding during Tropical Storm Lee in 2011 at Foxcroft Colony are shown in **Figure 3-4**.



Figure 3-4. Evidence of High Water Marks from 2011 Flooding at the Foxcroft Colony Condominiums

On September 6, 2008, Hurricane Hanna caused significant damage and flooding to 8 first-floor units in Buildings No. 55, No. 57 and No. 59 as well as inundating the southeast section of the community grounds and Old Pickett Road with several feet of water. A photograph from the Washington Post is provided in **Figure 3-5** showing flooding of the Foxcroft Colony southeastern parking lot area during Hurricane Hanna.



Figure 3-5. Photograph of Flooding during Hurricane Hanna at the Foxcroft Colony Condominiums

(Source: Washington Post)

3.4 Current Conditions

The area where the Foxcroft Colony Condominiums are located has a relatively high risk of flooding. The highest river stages on record have occurred in this location as a result of late summer hurricane and tropical storm events causing significant flood damages; the three most severe recent events are Hurricane Sandy, Tropical Storm Lee and Hurricane Hanna previously described. The Foxcroft Colony community will likely continue to be subjected to flooding and will rely on emergency responses to ensure the safety of the community.

The Foxcroft Colony Condominiums are located within the main creek watershed of the Accotink Creek. The total drainage area of the watershed to the point on the Accotink Creek near Foxcroft Colony is approximately 6 square miles. The drainage area is displayed on **Figure 3-6**. Business and residential development occupy most of the land in the watershed. This urbanized development has increased the imperviousness of the surfaces of the watershed.

The City participates in the Chesapeake Bay Resource Protection Area program. This program creates areas near streams that are part of the Chesapeake Bay drainage basin that remain free of development. The protection areas are typically located in the 1% annual change floodplain however may differ slightly in certain areas of the City.

The Foxcroft Colony Condominiums were built in the 1963, before the first Federal Emergency Management Agency (FEMA) Floodplain Insurance Studies (FIS) and flood insurance rate maps (FIRMs) were developed. The City of Fairfax FIS was last updated on June 2, 2006. The FIS covers the incorporated area of the City of Fairfax and is based on the original 1971 FIS.

According to FEMA's FIRMs for the City of Fairfax, last revised June 2, 2006, a portion of the Foxcroft Colony Condominium community is designed as Zone AE, which means that the area is in the 1% annual chance (100-year) floodplain. This also means that detailed hydrologic and hydraulic analyses have been completed for Zone AE; therefore, a 1% annual chance base flood elevations (BFEs) are known for Accotink Creek in the vicinity of Foxcroft Colony.

Based on effective FIRM and corresponding GIS data provided by Fairfax City, several buildings are located in and within the 100-year flood boundary, as shown in **Figure 3-7**.

As part of the FIS, FEMA prepared a hydrologic analysis to establish the peak discharge-frequency relationships for flooding sources studied in detail affecting the community. This hydrologic analysis was determined using the Hydrologic Engineering Center (HEC) – Hydrologic Modeling System (HMS) rainfall-runoff model developed by the U.S. Army Corps of Engineers (USACE). HEC-HMS is a computation based hydrologic model that simulates runoff from complex stream basin by representing the basin as an interconnected system of hydrologic and hydraulic components. The HEC-HMS model was completed in 1998 by Dewberry and Davis LLC for FEMA using the NRCS method in NRCS Technical Release 55 (TR-55).

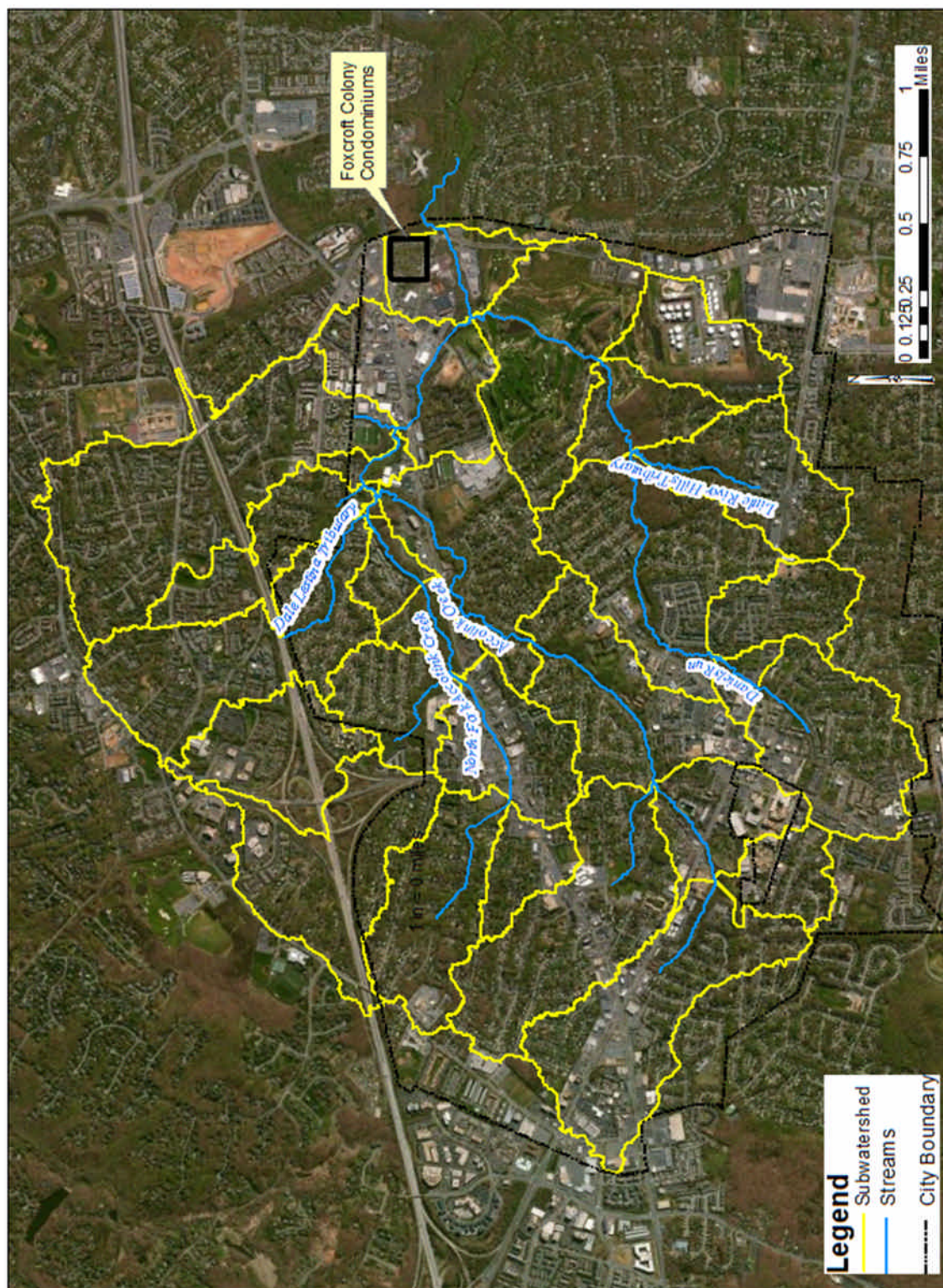




Figure 3-7. 100-Year Flood Boundary and BFEs at the Foxcroft Colony Condominiums

Per the FIS study, hydrologic data used in the HEC-HMS model were developed based on the following information: topographic mapping supported by digital orthophotos and digital terrain data with a 5-foot interval prepared by the City of Fairfax Department of Public Works, dated 1997; a report entitled *Soils of Fairfax County, General Ratings for Urban Development*, FCSSO, dated 1993; a Comprehensive Land Use Plan for the City of Fairfax, prepared by the City of Fairfax, dated 1997; hypothetical rainfall data from the National Weather Service’s Hydro-35, Technical Paper No. 40 (TP-40); and rainfall Intensity Duration Frequency (IDF) data from the Fairfax County Public Facilities Manual, Fairfax County, 1995. A summary of the drainage area peak discharge relationship reported in the FIS for a portion of the Accotink Creek near the Foxcroft Colony Condominiums are provided in **Table 3-1** below.

Table 3-1: FEMA FIS Drainage Area-Peak Discharge Relationship for a Portion of the Accotink Creek

Location	Distance from Foxcroft Colony ¹	Drainage Area	Peak Discharges (cfs)			
			10-year	50-year	100-year	500-year
Accotink Creek	(ft)	(Sq. mi.)				
Approx. 1,800 feet downstream of Picket Road	1,800 downstream	7.627	5,940	8,930	10,191	14,260
At Old Lee highway	2,000 upstream	4.884	4,580	6,700	7,590	10,560

¹ Distance from Foxcroft measured along Accotink Creek stream centerline

The hydraulic analysis performed for this FIS was developed in 1998 by Dewberry and Davis, LLC in the USACE Hydrologic Engineering Centers River Analysis System (HEC-RAS) program. Estimates of the flood and base water surface elevations for the recurrence intervals identified in **Table 3-4** were estimated using HEC-RAS and provided in the FIS. Locations of selected cross-section used in the hydraulic analysis are provided on the FIS Flood Profiles. A detailed study was conducted of the Accotink Creek from downstream of the corporate limits to a point approximately 250 feet upstream of Poplar Street.

Base water surface elevations (also known as base flood elevations (BFEs)) for the cross-section in the vicinity of Foxcroft Colony are provided in **Table 3-2** and are shown on **Figure 3-7**. The BFEs indicate the water surface elevation of the 100-year floodplain at the cross-section location. It is noted in the FIS that floodways were not calculated for any study area in the City of Fairfax.

Table 3-2: FIS Base Water Surface Elevations for Accotink Creek in Vicinity of Foxcroft Colony

Distance Above Corporate Limits (ft)	Distance from Foxcroft Colony Condominium Property (ft)	Base Water Surface Elevation (ft NGVD 1929)
0	461	289.1
611	150	290.2
762	0	290.8
1467	20	292.2
2481	1034	296.2

The flood profile for this area was obtained from the FEMA FIS for the City of Fairfax, dated June 2, 2006 (see **Figure 3-8**). The graph shows the elevation of the stream bed, the 10-year flood, the 50-year flood, the 100-year flood, and the 500-year flood over a 4,800-foot stretch of Accotink Creek. The x-axis shows the stream distance in feet above the corporate limits of Fairfax City where zero (at the origin of the graph) indicates the corporate limits. The Foxcroft Colony Condominiums (indicated in magenta on the graph) are located between Pickett Road (located 600 feet upstream of the corporate limits) and Old Lee Highway (located 3,200 feet above the corporate limits).

The condominiums shown in the graph are those along the transect A'-A and are shown in **Figure 3-7**. Because the finished floor elevations of the buildings were not available, this study relied on interpolating the lowest adjacent grade for each building based on topographic 2-foot interval contours GIS data provided by the City of Fairfax. The GIS data provided by the City is in vertical datum NAVD 1988.

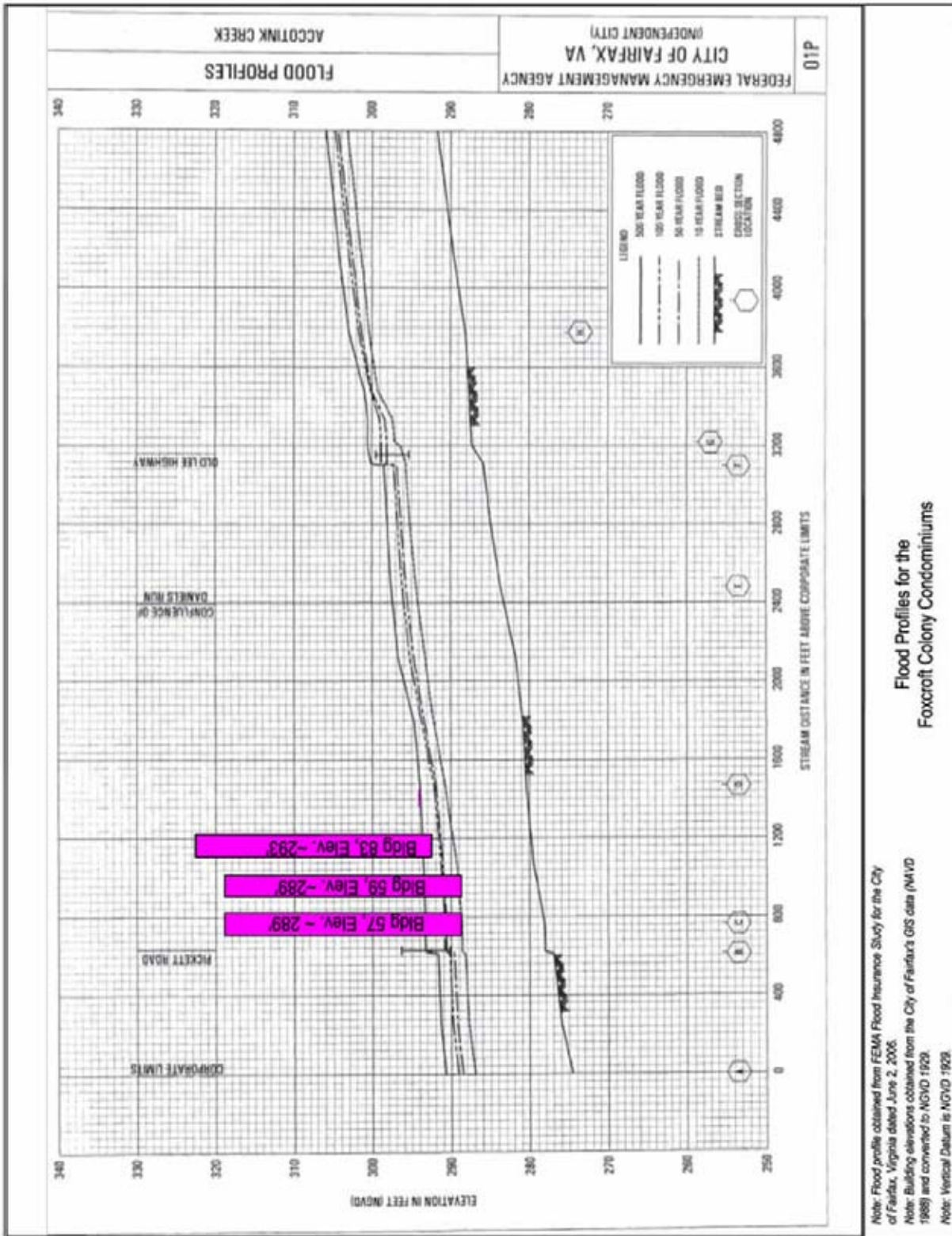


Figure 3-8. FEMA Flood Profiles for Accotink Creek with Foxcroft Colony Condominium Buildings

Based on the GIS contour data, it appears that lowest adjacent grade to Buildings 57 and 59, the southernmost and lowest elevation buildings (refer to **Figure 3-3** for building locations) is approximately elevation 288 ft NAVD 1988. Old Pickett Road varies in elevation with the lowest point at elevation 286 ft NAVD 1988 near the eastern corner of the Foxcroft Colony property and elevation 294 ft NAVD 1988 at the driveway of Foxcroft Colony on Old Pickett Road.

Because the FEMA FIS water surface elevations and profiles are represented in vertical datum NGVD 1929, the building elevations extracted from the City GIS data were converted to the NGVD 1929 data. The conversion between these two data at this location is approximately 0.77 feet (NAVD 1988 + 0.77 ft = NGVD 1929).

Based on these flood profiles, it appears that no buildings are located within the 10-year floodplain; however, 4 buildings are located within the 25-year floodplain, and 7 buildings are located within the 100-year floodplain. Water surface elevations for the 10-year, the 25-year, the 50-year, the 100-year and the 500-year recurrence events are reported in **Table 3-3** below. These elevations were extracted from the FIS HEC-RAS model.

Table 3-3: Water Surface Elevations At Foxcroft Colony Condominiums (ft NGVD 1929)

Cross-Section Location	10-Year	25-Year	50-Year	100-Year	500-Year
Immediately Upstream of Pickett road Crossing (no. 2385.523)	287.21	288.62	290.65	290.81	293.30
At Foxcroft Colony (no. 2692.773)	287.64	289.29	291.07	291.30	293.51

As discussed in Section 2.6, it is estimated that Hurricane Sandy (2012) is between a 10-year and 25-year, 24-hour event. Tropical Storm Lee(2011) and Hurricane Hanna (2008) both most closely resemble a 100-year, 12-hour event.

As mentioned, the lowest first-floor buildings' elevations are approximately at elevation 288 ft NAVD 1988 (or almost 289 ft NGVD 1929) which is between the 10-year and 25-year flood elevations in this area. Since Hurricane Sandy floodwaters were observed on the ground (close to, but not entering the units), it can be inferred that predicted conditons in the FIS closely match recent event conditions. Similarly, Tropical Storm Lee and Hurricane Hanna flooded the first-floor units by about 10 inches to 1 foot (around elevation 290 ft NGVD 1929) which is close to the predicted FIS flood levels at elevation 291 ft for the 100-year flood.

URS personnel performed field reconnaissance in January 2013 to investigate conditions of the Foxcroft Colony Condominium study area. During this investigation it was noted that a significant amount of sediment has been deposited in the Accotink Creek immediately upstream of Pickett Road Bridge crossing (refer to **Figure 3-9** and **Figure 3-10** showing conditions as of January 2013).



Figure 3-9. Pickett Road Bridge Crossing Over Accotink Creek (January 2013)



Figure 3-10. Pickett Road Bridge Crossing Over Accotink Creek (January 2013)

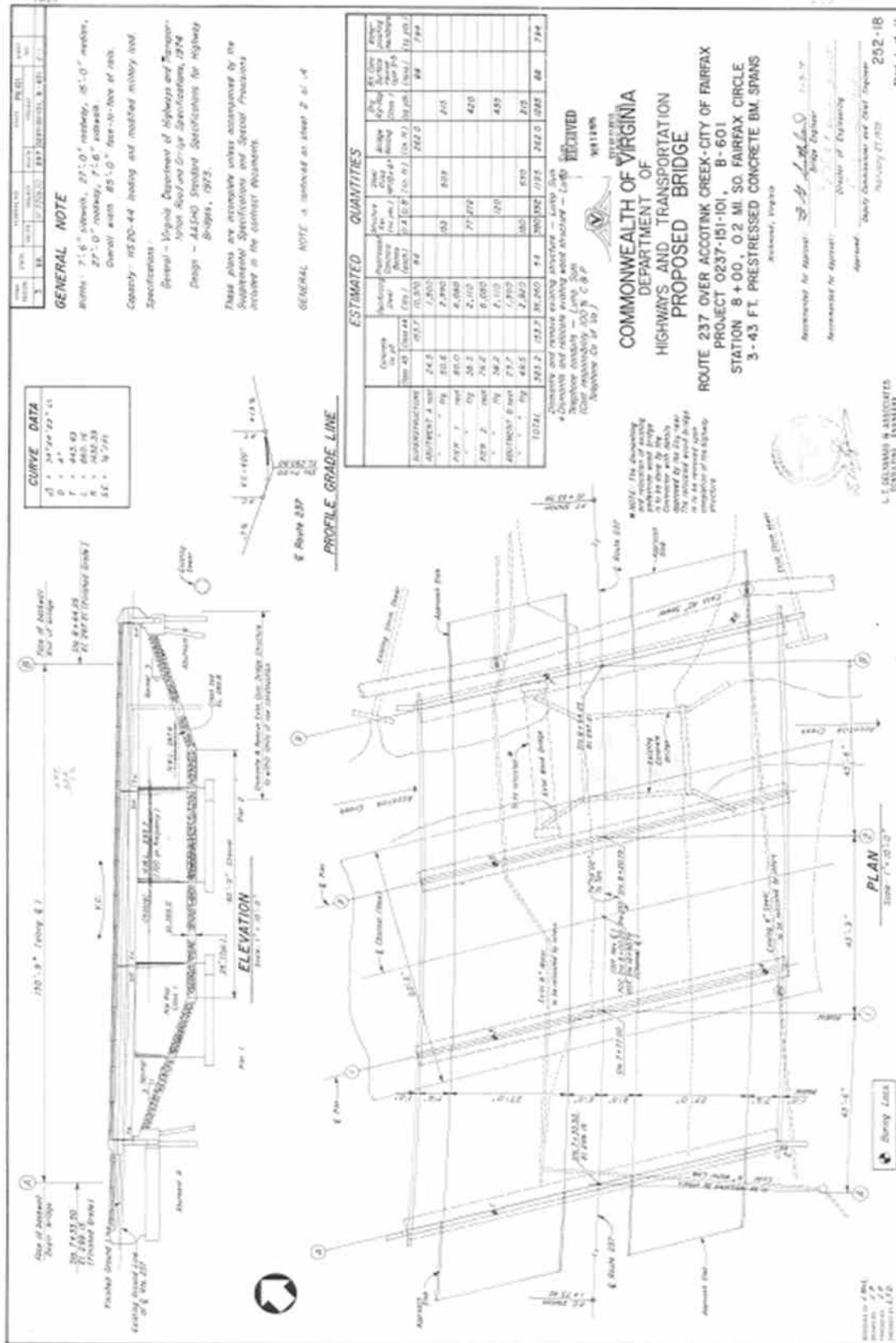
For comparison, aerial imagery retrieved from Bing.com (**Figure 3-11**) shows conditions of the Accotink Creek without sediment deposited in the creek immediately upstream of the bridge crossing. The sourced aerial imagery from Bing.com is undated.



Figure 3-11. 2012 Birds Eye View Aerial Imagery of Pickett Road Bridge Crossing at Accotink Creek

Pickett Road Bridge was rebuilt in the 1980s with a 60-foot flat channel bottom reinforced and 3:1 side slopes totaling a 120-foot opening (Refer to **Figure 3-12**). The plans show a bridge opening of around 11 feet at the channel invert. In comparison, the HEC-RAS model used to calculate BFEs for the FIS uses a bridge opening height of 12 feet and a width of 123 feet. Based on this comparison, it appears that the HEC-RAS model corresponds to the design plans. Refer to **Figure 3-13** and **Figure 3-14** for Bridge Cross-sections from the HEC-RAS model.

It is evident from reviewing the bridge design plans and the FEMA HEC-RAS model that the current conditions of the Accotink Creek at the Pickett Road crossing differs considerably due to excess sedimentation in the creek. Without a field survey, there is no way to know the amount of sediment accumulation immediately upstream of the bridge; however, based on field observation, it is believed that there is enough accumulation of sediment and debris to reduce the flow at the bridge during larger rain events. This accumulation may be causing the attenuation of floodwaters upstream of the Pickett Road Bridge crossing which in turn causes additional flooding of the floodplain at Foxcroft Colony. This accumulation may be a contributing factor as to why Foxcroft Colony has experienced increased flooding over the past several years.



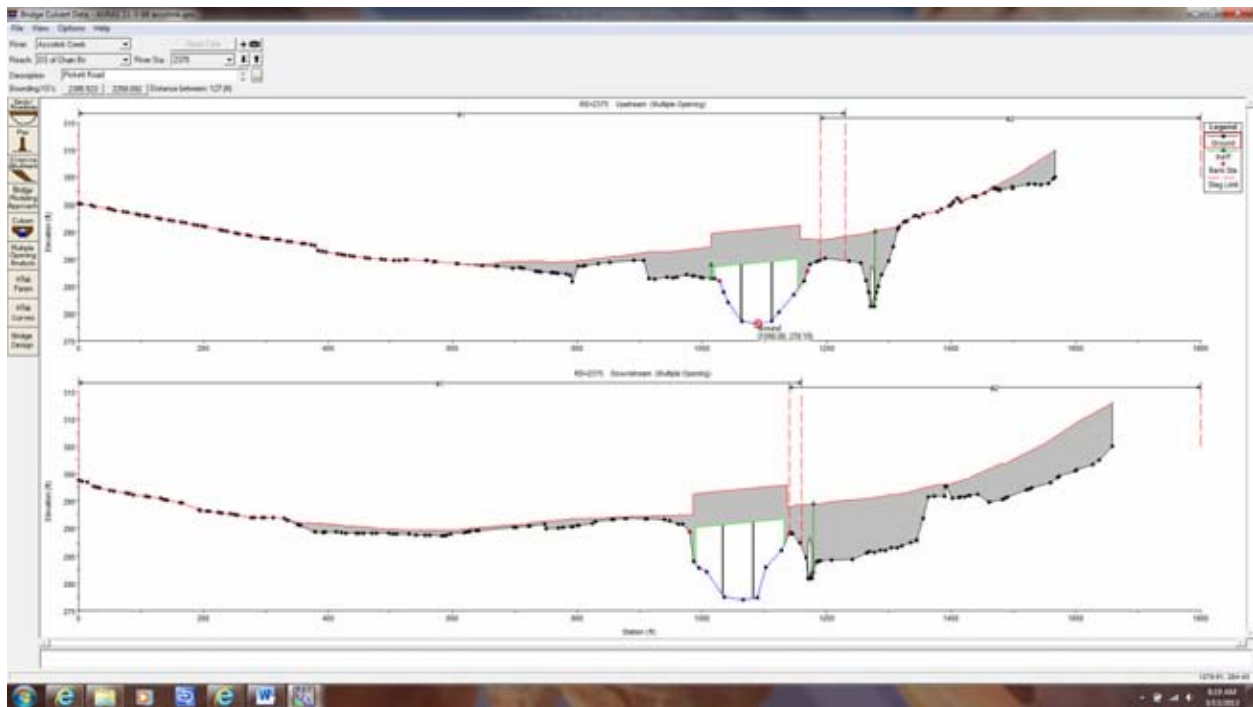


Figure 3-13. Full Cross-Section of Pickett Road over Accotink Creek from FEMA HEC-RAS Model

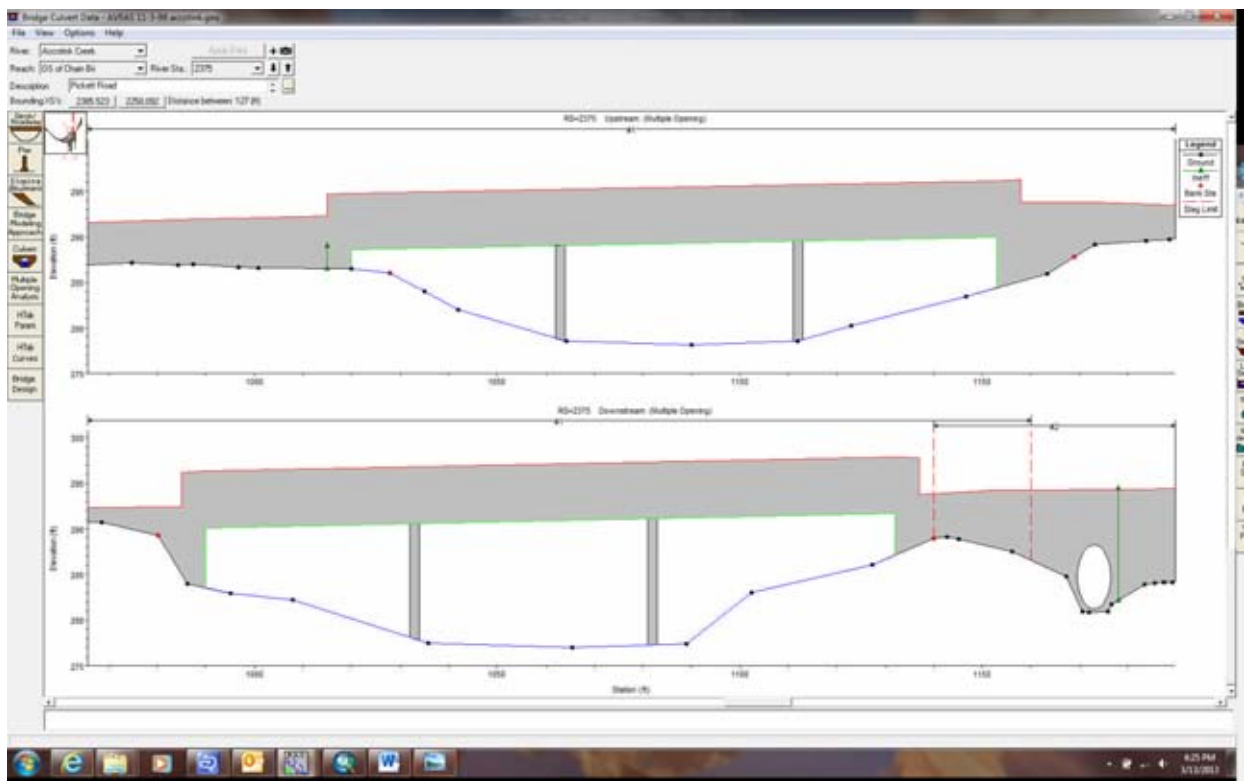


Figure 3-14. Pickett Road Bridge Opening over Accotink Creek from FEMA HEC-RAS Model

3.5 Alternatives Analysis

A wide variety of management measures were evaluated to address planning objectives. Alternative plans were then developed which comprised of one or more of the management measures. The alternative plans went through an initial screening that used the following criteria: effectiveness, environmental considerations, stakeholder impacts, and cost effectiveness. Each of these criteria is previously defined in Section 2.3. ROM costs were developed for each plan and potential Federal funding opportunities were evaluated. The initial screening resulted in three alternative plan design concepts which are being discussed in this analysis.

The study analyzed a number of possible types of measures and alternatives that could reduce the flood risk at the Foxcroft Colony Condominiums. These measures and plans included structural measures and non-structural measures, as well as increasing conveyance and flood storage.

Non-structural measures reduce flood risk by modifying the characteristics of the buildings and structures that are subject to floods or modifying the behavior of people living in or near the floodplains. In general, non-structural alternatives do not modify the characteristics of the flood. Non-structural measures include removing buildings from the floodplains by relocating or acquisition; flood-proofing buildings; elevating structures; implementing a flood warning system and preparedness activities; and implementing/enforcing floodplain regulations.

Structural measures reduce flood risk by modifying the characteristics of the flood. They often are employed to reduce peak flow (flood storage), direct floodwaters away from damageable property (Flood barriers), or to facilitate the flow of water through or around an area (channel modification or diversions). Several structural measures were considered as part of this analysis. The measures that were considered in this study for Foxcroft Colony are:

- Non-Structural
 - Flood-proofing structures in the floodplain
 - Acquiring (buy and relocate) flood-prone structures
 - Elevating structures in the floodplain
- Structural
 - Constructing a Levee system around a portion of the Foxcroft Colony property
 - Constructing a flood wall around a portion of the Foxcroft Colony property
 - Installing a backflow prevention device (valve or gate) on the stormwater conveyance system
- Increase conveyance
 - Increasing conveyance through Pickett Road Bridge
 - Adding conveyance under Pickett Road at the Foxcroft Colony Condominium property
 - Channelizing Accotink Creek
- Increase Flood Storage
 - Increasing on-line floodplain storage near the study area
 - Increasing the flood storage with a dam in Accotink Creek floodplain

Each of the potential flood mitigation measures listed above was preliminarily screened and either further evaluated or eliminated from further consideration. Refer to **Table 3-4** presenting a description and a preliminary screening analysis for each potential measure. The top three measures/plans were further evaluated as part of an alternative analysis which is described in the latter sections of this report.

To establish a baseline on to which to measure any proposed alternative, the current conditions or “no action alternative” is considered. The current conditions form the basis against which all proposed alternative plans are measured. Critical assumptions in defining the current conditions include:

- Emergency flood-fighting activities would continue to occur.
- Emergency flood-fighting measures have low effectiveness.
- Development in the floodplain will comply with local floodplain regulations; however, urban land use in the watershed will continue to occur which may increase floodplain elevations in the future.
- Flooding damages to the Foxcroft Colony units will continue.

Table 3-4: Flood Mitigation Measures Screening Matrix for Foxcroft Colony Condominiums

Alternative Measure / Plan	Alternative Type	Description	Analysis	Furthered Considered?
Flood-proofing structures in the floodplain	Non-Structural	Install flood-proofing measures on condominium buildings to prevent floodwater from entering structures.	Flood-proofing appears to prevent floodwaters from entering structures at the Foxcroft Colony area meeting a maximum 3-foot water depth requirement. To implement flood-proofing measures, coordination with private property owners is required. Seven buildings would be retrofitted under this plan.	Yes
Buy and relocate flood-prone structures	Non-Structural	Acquire flood-prone structures located in the floodplain.	With acquisition, the flood-prone area is returned back to a natural floodplain. This would require a total of 7 buildings with 84 units being acquired and demolished (28 of which are first-floor units located in the floodplain). Buildings not within the floodplain can remain. It is unlikely that this measure would be a cost-effective alternative.	No
Elevating Structures	Non-Structural	Elevate units on the first floor of buildings within the floodplain by abandoning the lower floor units and building a new story and relocating residents above the top story units.	This alternative would require abandonment of the 28 condominium units in the floodplain and adding a new story to the 7 existing buildings affected. However, it should be noted that under select conditions, elevating structures may potentially be eligible for federal funding through the FEMA HMA program. In order to be considered, a BCA must be completed to determine if this project would be eligible to apply for funding. Due to the extensive costs related to adding a new story to these buildings, it is unlikely that this option would be cost effective and therefore is not further considered.	No

Table 3-4: Flood Mitigation Measures Screening Matrix for Foxcroft Colony Condominiums

Alternative Measure / Plan	Alternative Type	Description	Analysis	Furthered Considered?
Levee system around a portion of Foxcroft Colony property	Structural	Install an earthen levee system along Old Pickett Road from the driveway entrance to the intersection of Pickett Road and long Pickett Road to elevation 292 ft, 1 foot about the 100-year floodplain water surface elevation.	This measure will protect Foxcroft Colony from flood events up to and including the 100-year event. Interior drainage must be removed with a pump station behind the levee. A drawback to a levee is the amount of property space required. Generally levees are at a slope of 1V:2H or 1V:3H with a 10 foot wide top, creating larger footprint than a floodwall. Due to space constrictions along Old Pickett Road this measure was eliminated.	No
Flood Wall system around a portion of Foxcroft Colony property	Structural	Install a flood wall along Old Pickett Road from the driveway entrance to the intersection of Pickett Road and long Pickett Road to elevation 292 feet, which is one foot above the 100-year floodplain water surface elevation.	This measure will protect Foxcroft Colony from flood events up to and including the 100-year event. As with levees, interior drainage removed with a pump station. A floodwall has a much smaller footprint than a levee and therefore is a more appropriate choice over a levee in this area and therefore selected for further consideration in this analysis.	Yes
Backflow prevention device on stormwater conveyance system	Structural – Local Drainage Modification	Install backflow prevention gate or valve on culvert south of Old Pickett Road and Pickett Road intersection.	A backflow prevention device such as a gate or valve will allow for storm drainage to flow out to Accotink Creek but prevent floodwaters entering back. This measure will only be effective for lower storm events since Old Pickett Road is overtopped during the 10-year event and above.	Yes

Table 3-4: Flood Mitigation Measures Screening Matrix for Foxcroft Colony Condominiums

Alternative Measure / Plan	Alternative Type	Description	Analysis	Furthered Considered?
Dredge Accotink Creek to Increase conveyance through Pickett Road Bridge	Increase Conveyance	Dredge a portion of the Accotink Creek upstream of the Pickett Road Bridge crossing to restore channel back to design conditions.	Sediment deposited upstream of Pickett Road bridge has reduced conveyance. Dredging the creek will help increase flow downstream alleviating flood storage upstream at lower storm events. This alternative has potential impacts to the environment and wetlands. Ongoing dredging and debris removal maintenance will likely be required. This measure is further considered since the Accotink Creek may continue to fill with sediment causing a further reduction in conveyance of floodwaters downstream of Pickett Road, potentially adding to the flood risk at the Foxcroft Colony property.	Yes
Adding conveyance under Pickett Road at Foxcroft Colony Condominium property	Increase Conveyance	Add conveyance under Pickett Road at the southeast corner of the Foxcroft Colony Condominium property by tunneling Pickett Road to divert floodwaters and storm drainage in storm sewer system under the roadway from the condominium property to the west side of Pickett Road.	It was estimated that at least four, 4-foot diameter storm sewer pipes would need to be installed under Pickett Road from the condominium property to the west side of the road at Thaiss Park to control drainage from the property. The BFE at the proposed outfall location is approximately 290 feet which is only 1 foot lower than the BFE at the condo property. The 1 foot elevation difference will not allow for significant conveyance of floodwaters during large events and there is significant cost required to complete this project. Therefore, this alternative is not recommended for further.	No

Table 3-4: Flood Mitigation Measures Screening Matrix for Foxcroft Colony Condominiums

Alternative Measure / Plan	Alternative Type	Description	Analysis	Furthered Considered?
Channelization	Increase Conveyance	Modify creek upstream of Pickett Road Bridge by activity such as widening and lining with concrete.	Widening the channel would be difficult due to the existence of the Pickett Road Bridge opening, and widening, even if possible, would likely increase sedimentation in this area. The only channelization activity that could possibly be effective in this area is to line the channel with concrete to speed up the flow and possibly reduce the water surface elevations. Creating a concrete channel would have significant impact on the environment and would be very costly. Due to the negative environmental impacts this alternative was eliminated.	No
On-Line Floodplain Storage	Increase Storage	Excavate to enlarge the floodplain storage near the confluence of the Accotink Creek and Daniels Run, downstream of the Army Navy Club.	There is limited area available for excavation. In addition, due to the large drainage areas of the Accotink Creek and Daniels Run, it is anticipated that on-line storage would have minimal effect on water surface elevations during large events.	No
Increase the flood storage with a Dam in Accotink Creek floodplain	Increase Storage	Construct a flood storage dam on the Accotink Creek downstream of the Army Navy Club.	In general, flood storage does not significantly reduce water surface elevations except in cases of large flood control reservoirs having significant flood storage volume with an outlet control structure or dam regulating flows downstream. Further, environmental impacts, significant property acquisition requirements and implementation costs would be required for this alternative, therefore it was not considered further.	No

3.5.1 Alternative Plan 1: Flood-Proofing Foxcroft Colony Condominium Buildings

Proposed Alternative Plan 1 consists of flood-proofing the buildings of Foxcroft Colony within the designated floodplain. Based on the effective FEMA FIRM, there are 28 first-floor condominium units in 7 buildings located in the 100-year floodplain, as shown in **Figure 3-15**. During past flood events flood waters have entered several of these units through the garden patio doors and the common utility room doors. Water has then traveled from the garden units through interior walls to adjacent units on the first floor.

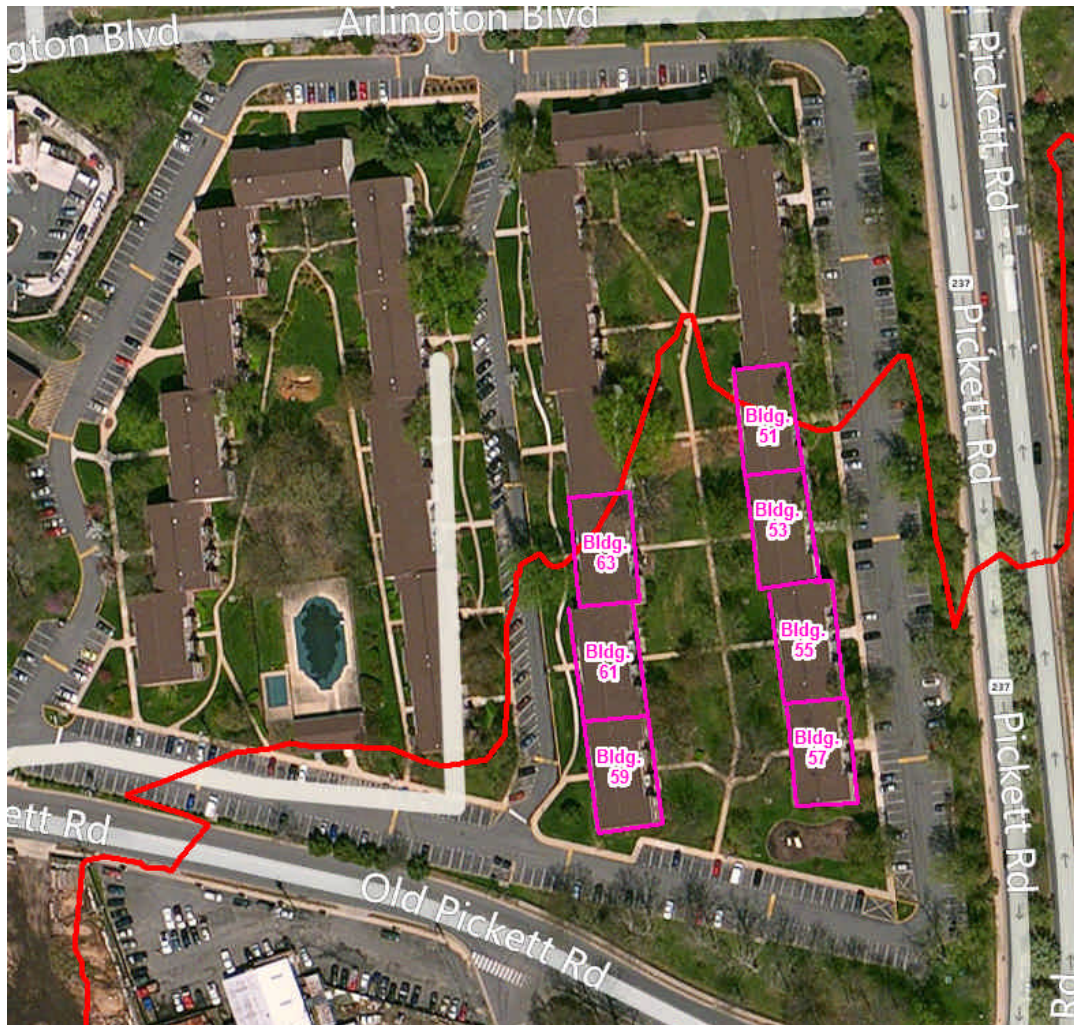


Figure 3-15. Foxcroft Colony Condominium Buildings to be Flood-proofed

The concept of flood-proofing typically involves sealing the exterior building wall with waterproofing compounds, impermeable sheeting, or other material and using shields to cover and protect openings from floodwaters. Shields can be used on doors, windows, vents, and other openings. Sewer lines may need to be fitted with check valves that close when flood waters rise in the sewer to prevent backup and flooding inside the building. Some examples of flood-proof doors and flood shields/barriers for door and window openings are shown in **Figure 3-16** below. The flood door shown is the Pedestrian Flood

Door manufactured by PS Doors. This door is a pre-hung normal use pedestrian door that also acts as a flood protection door. As long as the door is closed and latched, the area behind the door is protected from flooding. This type of door would work well for the entrance to the common utility room areas located on the first floor of each building and would replace the existing doors. Using a flood barrier plank system is an economical way to provide water protection to doors or openings when you want flood protection at the time of need only. Flood planks are a choice when it is not desirable or possible to store a flood barrier in a door or opening.



Figure 3-16. Typical Examples of Flood-proofing Doors and Barriers

(Source: <http://www.psddoors.com/flood-protection/>)

When evaluating the feasibility of flood-proofing techniques, there are important analysis/design criteria that must be considered such as flood characteristics (level, duration, and velocity); elevation of the first habitable flood, type and condition of construction, lot size, location and type of utilities and accessibility; building codes, zoning/site restrictions, flood insurance guidelines; and owner/community input and reasonable aesthetics.

Generally, dry flood-proofing should only be employed on buildings constructed of concrete block or brick on a wood frame. Weaker construction materials may fail at much lower water depths from hydrostatic pressure. Even brick or concrete block walls should not be flood-proofed above a height of approximately three feet, due to the danger of structural failure from hydrostatic forces, unless a structural engineer has confirmed that the building is designed to handle the forces.

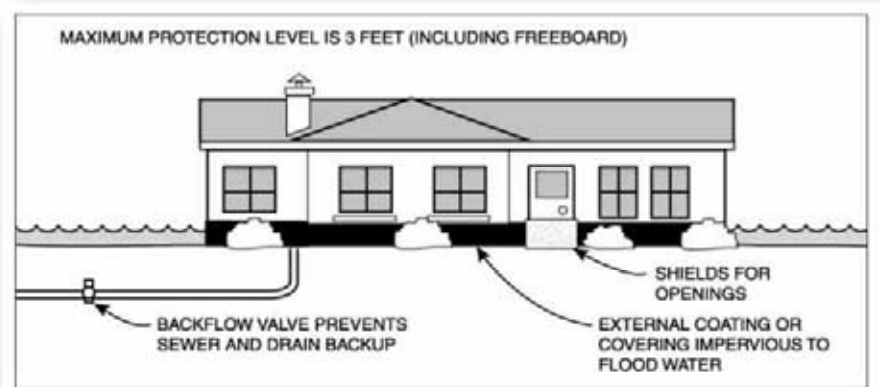


Figure 3-17. A Typical Dry Flood-proofed Structure

(Source: FEMA 512)

For this concept plan, a water proof membrane and protective covering (see **Figure 3-17**) would be applied to the exterior of the existing walls with the addition of flood barriers at the garden unit patio doors and windows and a water tight door at each utility room entry door. Various closure systems can be manufactured to fit the individual openings, providing a way for it to be quickly closed and have a water tight seal. These types of closures can either be stored in a readily accessible location or permanently remain in place. Many of these closures have rubberized seals and other components that will require periodic care and maintenance.

Dry flood-proofing the Foxcroft Colony Condominium buildings is a viable option since the buildings are constructed from concrete and brick materials and the flood waters of the 100-year floodplain are less than three feet deep at the buildings. The lowest first floor elevations of the buildings (bldg.. 57 and 59) located in the floodplain are located around elevation 288 feet NAVD 1988 (equivalent to 288.77 ft NGVD 1929 or approximately 289 ft) based on estimates of the lowest adjacent graded retrieved from the City's GIS data. The 1% annual change base flood elevation is approximately 291 feet NGVD 1929 at Foxcroft Colony which is about a 2-2.5 foot flood depth at the lowest units.

This plan was evaluated with the following criteria as described below: effectiveness, environmental considerations, stakeholder impacts, and cost effectiveness. Funding opportunities and ROM costs were also considered.

3.5.1.1 Effectiveness

Dry flood-proofing means that techniques are applied to keep floodwaters from entering the structure. This involves sealing the structure to keep floodwaters out and to keep the structure dry below the flood protection elevation. Flood-proofing would be designed to protect to an elevation of the 1% annual chance flood elevation; however, keeping water out is difficult and FEMA guidelines suggest it may not be effective. In addition, closure structures placed across all openings must be closed manually prior to a flood to be effective. The advantages and disadvantages of flood-proofing are summarized in **Table 3-5** below.

Table 3-5: Alternative Plan 1 Operational Advantages and Disadvantages¹

Advantages	Disadvantages
<ul style="list-style-type: none">• Dry flood-proofing is less costly than other retrofitting methods.• Does not require the additional land that may be needed for levees and floodwalls.• Easy to construct/install.• Often can be installed before other flood reduction measures such as levees and construction projects.	<ul style="list-style-type: none">• Dry flood-proofing requires human intervention and adequate warning to install protective measures.• Does <u>not</u> minimize the potential damage from high-velocity flood flow and wave action.• Does not protect grounds and surrounding areas outside of building.• Ongoing maintenance is required.• Flood shield may not be aesthetically pleasing.

¹FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding*

A disadvantage of this plan is that the vehicles and all other exterior areas are not protected. Another disadvantage to this plan is that it relies on manual operation to lift the closure shields on the doors and windows of each building. Property owners or onsite maintenance workers must be able to install flood shields and physically perform the activities required for the successful operation of the dry flood-proofing before the floodwaters arrive. While dry flood-proofing does require some maintenance, it is limited to cleaning and inspecting for leaking.

3.5.1.2 Initial Hydrology and Hydraulic Analysis

The proposed non-structural measure of flood-proofing does not alter the current hydrology or hydraulics of the study area therefore no analysis was conducted.

3.5.1.3 Environmental Considerations and Permitting

It is anticipated that this alternative measure will not have any direct or indirect negative impacts to the environment. It is not anticipated that any environmental permits are needed for implementing this measure.

3.5.1.4 Stakeholder Impacts

Stakeholders directly impacted by this plan include Foxcroft Colony residents located on the first floor of buildings in the floodplain. Other stakeholders, including Foxcroft Colony residents not located in the floodplain and the nearby commercial properties are not impacted by this plan.

During an initial meeting with the Foxcroft Colony Unit Owners Association on February 7, 2013 members expressed interest in the use of dry flood-proofing units within the designated floodplain using a closure shield system. Members understood that this method is limited in effectiveness due to manual operation of the closure shields. Members saw this measure as a lower-cost, short term remedial measure to reduce the risk of flooding units in the floodplain however highly prefer a permanent solution that protects the entire condominium property (grounds and parking area) that does not rely on mechanical operation and human intervention for successfully reducing flood risks.

3.5.1.5 Rough Order Magnitude Cost Estimate

To estimate the relative cost of a dry flood-proofing project, guidance from the following documents regarding general cost estimates were used: *FEMA 312, Homeowner's Guide to Retrofitting: Six Ways to Protect Your House From Flooding* and *FEMA 259, Engineering Principles and Practices of Retrofitting Floodprone Residential Structures* and *USACE's Flood-proofing – How to Evaluate Your Options*. To estimate the costs associated with closure gates on doors and windows, several manufactures' costs were evaluated. Typical costs associated with the following flood-proofing elements are provided below in **Table 3-6**. It is important to remember that costs are location and time dependent.

Table 3-6: General Estimates of Unit Costs for Typical Dry Flood-proofing Projects

Dry Flood-proofing Measure	Average Cost ¹
Waterproofing a concrete block or brick-faced wall by applying a polyethylene sheet or other impervious material and covering with a facing material such as brick	\$13.50/LF
Acrylic latex wall coating	\$3.00/LF
Caulking/sealant – high performance electrometric “urethane” sealant	\$2.50/LF
Bentonite grout (below grade waterproofing, 6 feet deep)	\$20/LF
Closure Gates, 6 foot for patio doors	\$800-\$1,200/each
Closure Door, unity door water tight	\$600-\$1,000/each

¹ FEMA 259, *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures*

Relative costs associated with this alternative plan are provided in **Table 3-7**. Based on the limited scope of this analysis, the project costs provided may vary depending on design elements not reviewed with this study. ROM costs for this alternative are \$68,000 for 7 buildings.

Table 3-7: ROM Costs for Dry Flood-proofing Foxcroft Colony Buildings

Dry Flood-proofing Measure	Number of Units	Measurement	Unit Cost	Approximate Cost
Waterproofing with a polyethylene sheet and a facing (3 feet high)	4450	LF	\$13.50	\$33,100
Caulking/sealant (door and window)	1550	LF	\$2.50	\$3,900
Closure Barrier, 3 foot for windows	56	Each	\$550	\$30,800
Closure Barrier, 6 foot for patio doors	16	Each	\$1,200	\$19,200
Closure Door, unity door water tight	7	Each	\$1,000	\$7,000
Engineering Design	1	Unit	\$20,000	\$20,000
Contingency (misc.)	1	Unit	\$15,000	\$15,000
Total ROM Costs				\$130,000

3.5.1.6 Cost Effectiveness

Based on the combination of the estimated cost of the project and the likelihood of cost-effectiveness, a related cost-effectiveness ranking of moderate is assigned.

3.5.1.7 Grant and Funding Opportunities

Dry flood-proofing residential structures does not qualify for funding support under the FEMA HMGP program. It should also be noted that there is no credit or reduction in flood insurance premiums for flood-proofed residential structures.

3.5.2 Alternative Plan 2: Increase Conveyance Capacity and Backflow Prevention Device

Proposed Alternative Plan 2 consists minor localized drainage improvements to increase the conveyance of flow on the Accotink Creek in the vicinity of Pickett Road Bridge by dredging the and installing a device backflow prevention device to prevent floodwater from the Accotink Creek floodplain at the culvert on the south side of Old Pickett Road (shown in **Figure 3-18**).



Figure 3-18. Culvert under Old Pickett Road at Intersection with Pickett Road

Installing a backflow prevention device such as a gate or valve, similar to the examples shown in **Figure 3-19** below would prevent flood waters from entering the Foxcroft Colony community from the existing drainage ditch and culvert system at the intersection of Old Pickett Road and Pickett Road. Storm events equivalent to and less than the 10-year event do not overtop Old Pickett Road therefore the

Foxcroft Colony community would not be affected by larger frequency flood waters from Accotink Creek with a backflow prevention device installed at the culvert shown in **Figure 3-18** above. The community grounds would continue to experience some drainage backup in the existing storm sewer system due to the inability of stormwater runoff to convey downstream from the ditch to Accotink Creek due to the backup of floodwaters during larger storm events.



Figure 3-19. Typical Examples of Stormwater Backflow Prevention Valve and Gate Devices
(Sources: <http://www.tideflex.com>, <http://www.awma.au.com/>)

3.5.2.1 Effectiveness

As discussed in Section 2.4, Current Conditions, it is believed that significant sediment and debris buildup immediately upstream of the Pickett Road bridge crossing over Accotink Creek is limiting the conveyance through the structure to that much less than per design conditions. It is believed that dredging a portion of the channel of the creek upstream of the bridge will allow more conveyance of flood waters, partially alleviating some of the flooding issues at and in the vicinity of Foxcroft Colony during storm events less than the 10-year event.

Dredging the Accotink Creek may alleviate flood issues for smaller storm events; however, due to the BFEs associated with the 100-year flood at 291 feet upstream and 289 feet downstream of Pickett Road, increasing conveyance through Pickett Road will have minimal effect on larger flood events due to current reduced capacity of flood flows to move downstream. Since Old Pickett Road is overtopped during the 10-year event, the Foxcroft Colony community may be flooded during larger flood events regardless if this plan is implemented or not. The advantages and disadvantages of this plan are summarized in **Table 3-8**.

This plan is an option that can be implemented in a schedule of approximately 2 years from design to construction depending on obtaining necessary permits for dredging activities. It must be considered that this alternative will not alleviate flooding of Foxcroft Colony community during flood events at the 10-year or greater reoccurrence interval and care must be given to sensitive environmental factors that may arise from dredging the creek.

Table 3-8: Alternative Plan 2 Operational Advantages and Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none">• Does not require continuous human intervention during a flood event such as flood-proofing methods.• Operation and maintenance requirements are low.• Helps protect community from more frequent flood events.	<ul style="list-style-type: none">• Does <u>not</u> minimize the potential risk from 10-year and greater flood events.• Direct impacts to the environment.• Is not as cost-effective as other alternative plans.• Dredging may require periodic routine maintenance to keep Creek free from sediment and debris buildup.

3.5.2.2 Initial Hydrology and Hydraulic Analysis

Hydraulic calculations were not conducted for this plan, however it is anticipated that installing a backflow prevention device on the culvert at the intersection of Pickett Road and Old Pickett Road and dredging the Accotink Creek channel will likely not have an impact to the 10-year and greater events. This plan will have a positive affect by reducing water surface elevations at the Foxcroft Colony property of flooding events more frequent than the 10-year event.

3.5.2.3 Environmental Considerations and Permitting

It is anticipated that this alternative plan will have direct impacts to the environment. Dredging the Accotink Creek to remove the sediment accumulation will affect natural vegetation that has begun to grow on the channel banks and channel bottom. Identification of wetlands must be conducted in the area designated for dredging to determine what kind, if any, of wetlands are presented and the extents of the wetland habitat. It is anticipated that environmental permits from the state or federal government are needed to implement this measure.

Depending on the identification of wetlands in the creek a permit may be required for wetlands disturbance. Two permits are generally required for work that impacts wetlands, a Section 404 permit and a Section 401 permit. "404" refers to Section 404 of the Clean Water Act and likewise, "401" refers to Section 401 of the Clean Water Act. USACE administers Section 404 permits, which are required for the discharge of fill material into streams, wetlands and open waters. In Virginia, the DEQ's Office of Wetland and Stream Protection (OWSP) administers the Virginia Water Protection Permit (VWPP) program, which serves as Virginia's Section 401 certification program for federal Section 404 permits issued under the authority of the Clean Water Act. Typically, if USACE determines that a 404 Permit is required because the proposed project involves impacts to wetlands or waters, then a 401 permit is also required.

In addition to State and Federal wetlands permits, local permits for development in the floodplain and designated RPA zone may be required.

3.5.2.4 Stakeholder Impacts

Impact to stakeholders based on implementation of this plan include increased protection from flood events more frequent than the 10-year. Stakeholders outside of the Foxcroft Colony community (nearby commercial properties) are not impacted by this alternative plan.

3.5.2.5 Rough Order Magnitude Cost Estimate

Relative costs associated with this alternative plan are provided in **Table 3-9**. Based on the limited scope of this analysis, the project costs provided may vary depending on design elements not reviewed in this study. ROM costs for this alternative are \$726,000.

Table 3-9: ROM Costs for Increasing Conveyance Capacity and Backflow Prevention Device

Measure	Number of Units	Measurement	Unit Cost	Cost
Dredging (600 lf x 45lf width x 3ft avg. depth) includes excavation and disposal	3,000	CY	\$15	\$450,000
Channel restoration (regarding banks)	600	LF	\$100	60,000
Backflow prevention valve fitted to a 42" culvert, installed	1	Each	\$3,000	\$3,000
Preconstruction Engineering and Design ¹	1	Unit	\$100,000	\$100,000
Construction Management ²	1	Unit	\$51,000	\$51,000
Contingency (10%)	1	%	10%	\$62,000
Total ROM Costs				\$726,000

¹ PED is to complete the final design, prepare permit applications and prepare the plans and specifications.

² Construction Management is estimated to be 10% of the project construction.

3.5.2.6 Cost Effectiveness

Based on the total cost of this plan, and its ability to only protect the Foxcroft Colony community from floods less than the 10-year event, this plan is assigned a cost effectiveness rating of low.

3.5.2.7 Grant and Funding Opportunities

Minor localized flood reduction projects such as dredging and drainage modifications including backflow prevention devices may be funded by the FEMA HMS under the HMGP, PDM and FMA programs. In particular, eligible PDM program projects include stormwater management projects to reduce or eliminate long-term risk from flood hazards and localized flood reduction projects that are designed specifically to protect critical facilities and that do not constitute a section of a larger flood control system. In general, HMA funds may be used to pay up to 75 percent of the eligible activity costs. The remaining 25 percent of eligible costs are derived from non-Federal sources.

A more thorough analysis must be completed to determine if this plan would meet FEMA's eligibility criteria and what funds, if any, are viable at this time. If the City moves forward with this alternative plan, it is recommended that a BCA is completed to determine eligibility.

3.5.3 Alternative Plan 3: Install Floodwall at Property Line and a Backflow Valve on Culvert

Proposed Alternative Plan 3 includes installing a floodwall along the southern and a portion of the eastern property line of the Foxcroft Colony community to an elevation one foot above the 100-year base flood elevation and installing a backflow prevention device on the culvert south of Old Pickett Road at the intersection with Pickett Road (refer to **Figure 3-18**), similar to that proposed in Alternative Plan 2.

A 1,060 foot floodwall is proposed along the southern property line adjacent to Old Pickett Road from the community's driveway to the intersection of Old Pickett Road and Pickett Road and along Pickett Road to the north approximately two-thirds up the property line (refer to **Figure 3-20**). The floodwall will act as a barrier protecting the area behind the wall from flooding during the 100-year and lesser events. Examples of typical floodwalls are provided in **Figure 3-21**. Similar to levees, floodwalls keeps water away from buildings. However, floodwalls take less space and generally require less maintenance than earthen levees. Floodwalls can be constructed using a variety of designs and materials, such as steel sheet piles and concrete. Floodwalls are typically more expensive than levees so are a preferred option over a levee when space is limited.

Old Pickett Road varies in elevation with the lowest point at elevation 286ft near the eastern corner of Foxcroft Colony property and elevation 294ft at the driveway of Foxcroft Colony on Old Pickett Road therefore the floodwall will tie into a point of elevation 292ft and be approximately six feet high at its tallest point. Since the floodwall is proposed at an elevation one foot above the 100-year BFE, the proposed design would not meet FEMA certification requirements and the Foxcroft Colony residents in the floodplain would still be required to purchase flood insurance.

Interior drainage behind the floodwall will continue to be collected in the existing storm sewer system on the property grounds. This system drains the southeast corner of the property near the intersection of Old Pickett Road and Pickett Road through a 42-inch diameter culvert to the drainage ditch south of Old Pickett Road.

As part of this plan the interior drainage would have to be modified and sump pumps with emergency power would be installed. The stormwater and sanitary sewer systems would be modified to prevent the backflow of the flood waters. A pump station is proposed to pump interior drainage from the Foxcroft Colony community grounds collected at the southeastern corner over the floodwall. The pump shall be sized to have enough capacity to drain a 100-year flood event from behind the wall.

As discussed previously, stormwater runoff will raise the water level in the Accotink Creek and the drainage ditch immediately upstream of Pickett Road hydraulically connecting the Foxcroft Colony community storm sewer lines to the Accotink Creek. Installing a backflow prevention gate or valve, similar to the examples shown in **Figure 3-19**, would reduce the flood waters entering the Foxcroft Colony community from the existing drainage ditch and culvert system at the intersection of Old Pickett Road and Pickett Road.



Figure 3-20. Proposed Concept Plan – Alternative Plan 3 Floodwall and Pump Station



Figure 3-21. Example of Typical Floodwall

3.5.3.1 Effectiveness

This alternative plan is an effective solution allowing reduced flooding during, and less than, the 100 year event. A floodwall is a permanent structural measure that requires little maintenance to be effective.

There are minimal risks associated with this plan since the community is protected from the 100-year event and the surrounding areas will not experience an increase in flooding due to this project. O&M requirements are very low for both the floodwall and the backflow prevention valve.

The advantages and disadvantages of this plan are summarized in **Table 3-10** below.

Table 3-10: Alternative Plan 3 Operational Advantages and Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none"> Does not require continuous human intervention during a flood event such as flood-proofing methods. Helps protect community from the 100-year flood event. 	<ul style="list-style-type: none"> May have direct impacts to the environment. Is costly to construct. Will take several years to implement between design and construction. Requires periodic maintenance.

3.5.3.2 Initial Hydrology and Hydraulic Analysis

A limited hydraulic analysis was conducted for this feasibility analysis to identify water depths and any change in the floodplain for a range of hydrologic events with the proposed floodwall with a top elevation of 292ft, one foot above the elevation of the 100-year BFE in this area. Based on this limited review, it appears that the proposed floodwall has minimal effects on the BFEs of the floodplain as shown in **Table 3-11**.

Table 3-11: Current vs. Proposed Water Surface Elevations at Foxcroft Colony Condominiums

Current/ Proposed	10-Year	25-Year	50-Year	100-Year	500-Year
Upstream of Pickett Road Crossing (Cross-Section no. 2385.523)					
Current	287.21	288.62	290.65	290.81	293.30
Proposed	287.21	288.62	290.67	290.83	293.35
Difference in WSE (ft)	0.00	0.00	0.02	0.02	0.05
At Foxcroft Colony (Cross-Section no. 2692.773)					
Current	287.64	289.29	291.07	291.30	293.51
Proposed	287.64	289.29	291.09	291.39	293.61
Difference in WSE (ft)	0.00	0.00	0.02	0.09	0.10

Note: Elevations reported in NGVD 1929. Current are those WSEs reported in the FIS HEC-RAS model. Proposed is the WSEs estimated with a proposed floodwall at Foxcroft Colony per Alternative Plan 3 conditions.

A very rough calculation was completed on the interior drainage area of Foxcroft Colony to confirm that the quantity of stormwater runoff onsite will not flood buildings during the 100-year event. This is based on the assumption that the floodwaters on of Accotink are at the elevation 291.0 ft on the river-side of the floodwall and that no runoff from Foxcroft Colony can drain to the river-side of the floodwall due to the backup of floodwaters to the BFE elevation. This Calculation was computed to determine if a pump station was needed to handle interior drainage. The information provided in **Table 3-12** was used to calculate the 100-year interior drainage.

Table 3-12: Interior Drainage Calculations at Foxcroft Colony

Calculation Measure	Value
Drainage Area	13 acres
Rainfall Intensity (i) for 100-Yr	8.25 in/hr
Rational Method Runoff Coefficient (c.)	0.75 (residential area)
Correction Factor for Ground Saturation (cf)	1.25
Peak Flow Rate (Q) $Q=ciA * cf$	100 cfs

3.5.3.3 Environmental Considerations and Permitting

It is anticipated that this alternative plan will have direct impacts to the environment and the surroundings. It appears there may be a small pocket of cattail species in the southeastern corner of the Foxcroft Colony property. It is anticipated that environmental permits from the state or federal government are needed to implement this measure.

Depending on the identification of wetlands in the creek a permit may be required for wetlands disturbance. Two permits are generally required for work that impacts wetlands, a Section 404 permit and a Section 401 permit. "404" refers to Section 404 of the Clean Water Act and likewise, "401" refers to Section 401 of the Clean Water Act. USACE administers Section 404 permits, which are required for the discharge of fill material into streams, wetlands and open waters. In Virginia, the DEQ's Office of Wetland and Stream Protection (OWSP) administers the Virginia Water Protection Permit (VWPP) program, which serves as Virginia's Section 401 certification program for federal Section 404 permits issued under the authority of the Clean Water Act. Typically, if USACE determines that a 404 Permit is required because the proposed project involves impacts to wetlands or waters, then a 401 permit is also required. In addition to State and Federal wetlands permits, local permits for development in the floodplain and designated RPA zone may be required.

3.5.3.4 Stakeholder Impacts

Residents of the Foxcroft Colony condominiums would be protected from the 100-year flood from the Accotink Creek with the floodwall in place. Interior stormwater drainage would be the only impact to residents. Non-Foxcroft Colony resident stakeholders, including nearby property owners, would not be impacted by the proposed alternative plan since it is not anticipated that the water surface elevation will increase.

3.5.3.5 Rough Order Magnitude Cost Estimate

Relative costs associated with this alternative plan are provided in **Table 3-13**. Based on the limited scope of this Analysis, the project costs provided may vary depending on design elements not reviewed with this study. ROM costs for this alternative are around \$3 million.

Table 3-13: ROM Costs for Floodwall and Pump Station at Foxcroft Colony Condominiums

Measure	Number of Units	Measure	Unit Cost	Cost
Floodwall (4 ft avg. height wall with base)	1,060	LF	\$800.00	\$848,000
Excavation for floodwall and pump station	1000	CY	\$11	\$11,000
Pump station and features	1	Each	\$1,150,000	\$1,150,000
Backflow prevention valve fitted to a 42" culvert, installed	1	Each	\$3,000	\$3,000
Stormwater sewer system reconfiguration	1	Each	\$45,000	\$45,000
Site features (landscaping, pavement, etc.)	1	Unit	\$225,000	\$225,000
Lands, Easements, and Rights of Way	1	Unit	\$75,000	\$75,000
Preconstruction Engineering and Design ¹	1	Unit	\$400,000	\$400,000
Construction Management ²	1	Unit	\$240,000	\$240,000
Contingency	1	10%		\$300,000
Total ROM Costs				\$3,330,000

¹ PED is to complete the final design, prepare permit applications and prepare the plans and specifications.

² Construction Management is estimated to be 10% of the project construction.

3.5.3.6 Grant and Funding Opportunities

Eligible activities that may be funded by FEMA's HMA programs vary by program and mitigation activity. This plan, including the floodwall and pump station may be considered a minor localized flood reduction project and possibly funded under the HMA program. In order to determine if this plan is eligible, it

must be carried to a design level where all project elements and costs are defined. An economic analysis or BCA of potential flood damage reduction benefit in the floodplain will be necessary to determine if this plan would be potentially eligible for funding support. A plan must have a benefit cost ratio greater than one, or net benefit greater than zero, to be justified.

3.5.3.7 Cost Effectiveness

This plan potentially has the highest level of risk reduction from the 100-year flood event when compared to other plans evaluated for this study area. However, due to the costs associated with a floodwall and pump station to protect the Foxcroft Colony community, this plan is assigned a moderately low cost effectiveness ranking.

3.6 Recommendations

Three alternative plans are recommended for the Foxcroft Colony Condominiums which vary in cost and risk mitigation. The recommended plan for the Foxcroft Colony study area is dependent of the funding available to support the project.

Alternative Plan 1 is to flood-proof the buildings with an estimated cost of about \$130,000. There are both advantages and disadvantages to this plan. The main advantage to this plan is the low costs when compared to other alternative plans evaluated for this study area. The main disadvantage is that human intervention is required to set up the flood barriers at the windows and patio doors of units in the floodplain. Since the barriers rely on either a closure gate that must be lifted or planks that must be inserted into permanent sidebars, they are temporary and must be installed prior to a flood event. However, if implemented correctly, this plan will reduce the flood risk to Foxcroft Colony residents located in the floodplain. It should be noted that residents in the floodplain should continue to purchase flood insurance since flood-proofing is not a FEMA-recognized method to remove buildings from the floodplain.

Alternative Plan 2 consists of minor localized drainage improvements to increase the conveyance of flow on the Accotink Creek including dredging a portion of the creek and a device backflow prevention device to prevent floodwater from the Accotink Creek floodplain at the Foxcroft Colony community. Rough order of magnitude costs for this alternative are \$726,000.

The third option (Alternative Plan 3) is to install a floodwall along Old Pickett Road and a portion of Pickett Road to block floodwaters from entering Foxcroft Colony grounds. A pump station is necessary to remove any interior drainage collected behind the floodwall. If designed to FEMA standards for certification, the flood wall may be eligible for FEMA grant funding support. Estimated costs for the floodwall and pump station are approximately \$3 million. Alternative Plan 3 would provide the highest degree of flood risk reduction, protecting the community from the 100-year flood.

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4 Mosby Woods Condominiums

The primary problem identified in the study area is a high risk of flood damage to the Mosby Woods Condominiums along the North Fork Accotink Creek. The following sections provide information describing the study area location, identifies representative stakeholders, and provides a description on the history of the flooding issues at the Mosby Woods Condominiums.

4.1 Location of the Study Area

The Mosby Woods Condominiums are located in Fairfax City, Virginia approximately three miles west of Interstate 495, the Capital Beltway, near the intersection of Route 29 Fairfax Boulevard and Route 123 Chain Bridge Road. The Mosby Woods Condominiums are comprised of eight clusters of buildings located along Mosby Woods Drive between Plantation Parkway and Stafford Drive (see **Figure 4-1**). Onsite amenities include a pool, pool building, and basketball court. North Fork Accotink Creek runs along the southern edge of the Mosby Woods community. For additional photographs of this study area taken at time of field investigation on January 23, 2013, refer to **Appendix C**. The condominium complex is surrounded by single family homes to the north, east and west. To the south there are a sports field and commercial properties located on Route 29.

4.2 Stakeholders

There are many stakeholders associated with this study area in addition to Mosby Woods' residents since flood control projects could affect the floodplain and elevation of floods in the vicinity of the Mosby Woods community. The following have direct involvement at the Mosby Woods Condominiums study area:

- City of Fairfax
- Mosby Woods Condominium residents and Board of Directors
- TWC Association Management Agent

4.3 History of the Flooding

Over the past seven years, there have been three rainfall events that have caused flooding at the Mosby Woods Condominiums. Other storm events have also caused flooding on property grounds. This study will be limited to the three events that caused the most significant recent flooding which affected habitable structures. The most recent rainfall event was Hurricane Sandy on October 26, 2012. Hurricane Sandy caused floodwaters that came very close to the condominiums but did not cause damage. Tropical Storm Lee caused major flooding on September 8, 2011 inundating 7 condominium units by several inches. In 2006 an unnamed tropical cyclone caused significant flooding of approximately 2 feet in 7 of the condominium units.

During a meeting with the Mosby Woods Condominium Board of Directors, member indicated that flooding has only been an issue at this site for the past seven years. No flood issues were reported for at least thirty years prior to an unnamed tropical cyclone in 2006. Units that have had repeated flooding are unit number located on the first floor of the buildings highlighted in **Figure 4-2**. Flood waters have entered the units through the front doors and also through vents associated with the units' furnaces.



Figure 4-1. Vicinity Map of Mosby Woods Condominiums



Figure 4-2. Buildings Affected by Historical Flooding at Mosby Woods Condominiums

Board members indicated that the creek has changed from relatively straight to a “horseshoe” shape, as shown in **Figure 4-2** and that sediment deposition has affect the channel. This change in topography has brought the creek closer to the condominiums in that area and has also destroyed space that was previously utilized by the residents, including an area where flower bulbs and trees were planted.

4.4 Current Conditions

The Mosby Woods area could experience significant flooding similar to the 2006, 2011, and 2012 flooding events, which caused damage to property. Without a comprehensive flood risk management project in this area, the Mosby Woods community will likely continue to be subject to flooding and will rely on emergency responses to ensure the safety of the community.

Mosby Woods Condominiums is located within the North Fork Accotink Creek watershed. The watershed extends in the easterly direction to the confluence with Mosby Woods Tributary and in the westerly direction to the confluence of the North Fork with Accotink Creek. The total drainage area of the watershed to the point on the Accotink Creek at Mosby Woods is approximately 575 acres which is displayed on **Figure 4-3**. Business and residential development occupy most of the land in the watershed. This urbanized development has increased the imperviousness of the surfaces of the watershed. The City participates in the Chesapeake Bay Resource Protection Area program. This program creates areas near streams that are part of the Chesapeake Bay drainage basin that remain free of development. The protection areas are typically located in the 100-year floodplain.

According to FEMA’s FIRMs for the City of Fairfax, the majority of the Mosby Woods Condominiums is designed as Zone AE, which means that area is in the 1% annual chance (100-year) floodplain. Zone AE means that a detailed hydrologic and hydraulic analysis has been completed, so 1% annual chance BFEs are known for North Fork Accotink Creek in the vicinity of Mosby Woods. A detailed study was conducted of North Fork from the confluence with Accotink Creek to a point approximately 850 feet upstream of Howerton Avenue. Based on effective FIRM and corresponding GIS data provided by the Fairfax City, several buildings (buildings numbered 1 -7) are located in within the 100-year flood boundary, as shown in **Figure 4-4**.

As part of the FIS, FEMA prepared a hydrologic analysis for the North Fork Accotink Creek to establish the peak discharge-frequency relationships for flooding sources studied in detail affecting the community. This hydrologic analysis was determined using the HEC-HMS rainfall-runoff model developed by the USACE. The HEC-HMS model was completed in 1998 by Dewberry and Davis LLC for FEMA using the NRCS method in NRCS Technical Release 55 (TR-55).

A summary of the drainage area-peak discharge relationship for a portion of the North Fork Accotink Creek reported in the FIS are provided in **Table 4-1** below.

Table 4-1: FEMA FIS Drainage Area-Peak Discharge Relationship for a Portion of North Fork Accotink Creek

Location	Distance from Mosby Woods ¹ (ft.)	Drainage Area (Sq. mi.)	Peak Discharges (cfs)			
			10-year	50-year	100-year	500-year
At confluence with Accotink Creek	1,000 downstream	1.94	2,010	2,680	2,960	4,020
At Eaton Place	2,500 upstream	0.60	1,000	1,490	1,700	2,240

¹ Distance from Mosby Woods measured along the North Fork Accotink Creek stream centerline.

The hydraulic analysis performed for this FIS was developed in 1998 by Dewberry and Davis LLC using the USACE HEC-RAS River Analysis System program. Estimates of the flood and base water surface elevations for the reoccurrence intervals identified in **Table 4-1**, above were estimated using HEC-RAS and provided in the FIS. Locations of selected cross-section used in the hydraulic analysis are provided on the FIS Flood Profiles.

Base water surface elevations (also known as BFEs) for cross-sections in the vicinity of Mosby Woods are provided in **Table 4-2** below. Cross-Section locations are represented on the FIS profile shown in **Figure 4-5**. The BFEs indicate the water surface elevation of the 100-year floodplain at the cross-section location. It is noted in the FIS that floodways were not calculated for any stream in the City of Fairfax.

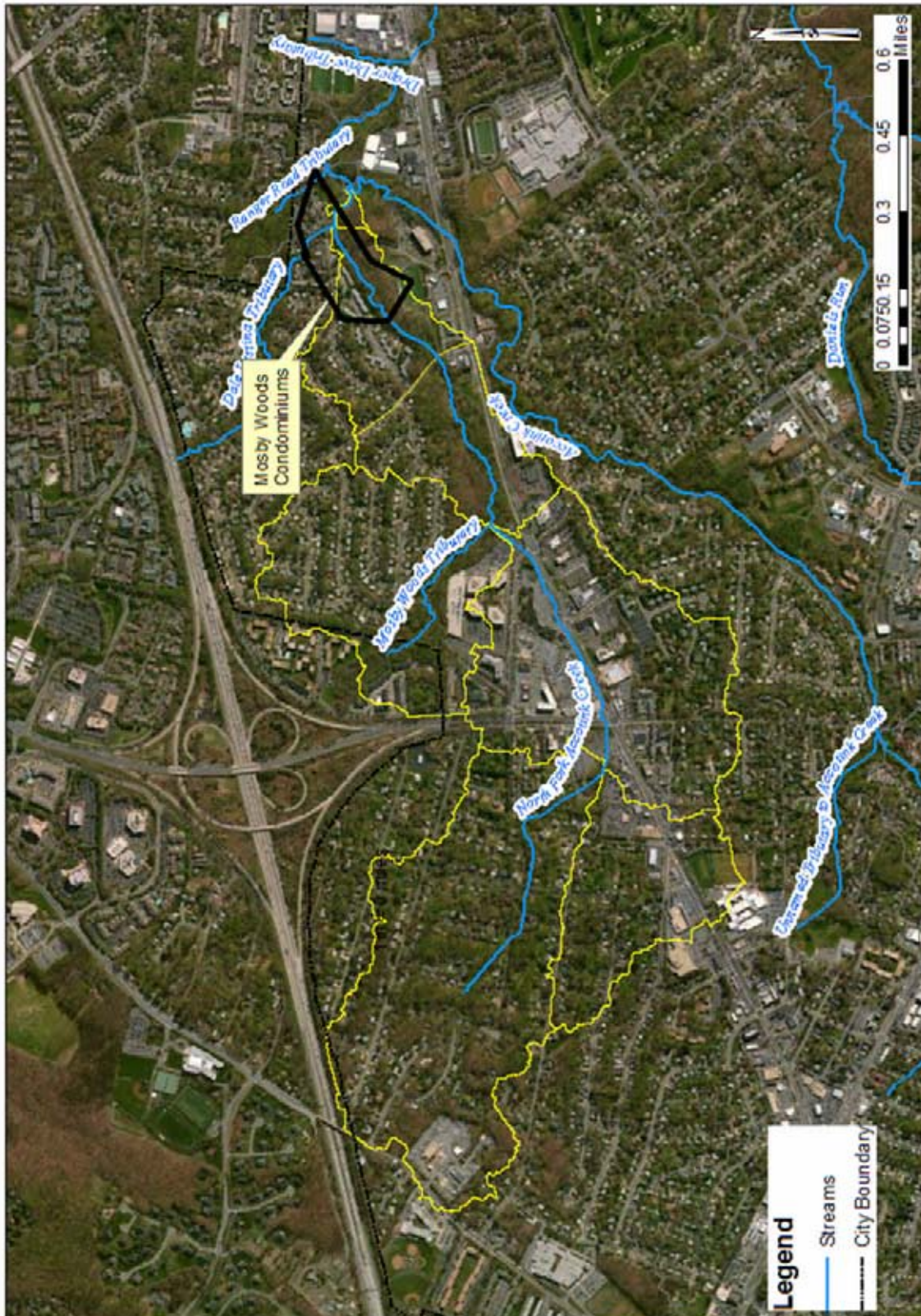


Figure 4-3. North Fork Accotink Creek Drainage Area Map



Figure 4-4. 100-Year Flood Boundary and BFEs at the Mosby Woods Condominiums

Table 4-2: FIS Base Water Surface Elevations for North Fork Accotink Creek in Vicinity of Mosby Woods

Distance Above Confluence with Accotink Creek (ft)	Distance from Mosby Woods Condominium Property	Base Water Surface Elevation (ft NGVD 1929)
807 (Cross-Section B)	100	315.2
936 (Cross-Section C)	0	321.9
2,365 (Cross-Section D)	150	322.7
2504 (Cross-Section E)	250	328.9

To gain further understanding of the hydraulics at Mosby Woods, the flood profile for this area was obtained from the FEMA FIS for the City of Fairfax, dated June 2, 2006 (see **Figure 4-5**). The graph shows the elevation of the stream bed, 10-year flood, 50-year flood, 100-year flood, and 500-year flood over a 2,600-foot stretch of North Fork. The x-axis shows the stream distance in feet above the confluence with the Accotink Creek, where zero (at the origin of the graph) indicates the confluence. The Mosby Woods Condominiums (indicated in magenta on the graph) are located between the culvert at Stafford drive, located 800 feet upstream above the confluence, and the culvert at Plantation Parkway, located 2400 feet above the confluence.

The condominium buildings shown in the graph are those along the transect A'-A and are shown in **Figure 4-4**. Since finished floor elevations of the buildings were not available, this study relied on interpolating the lowest adjacent grade for each building based on topographic 2-foot interval contours GIS data provided by the City of Fairfax. GIS data provided by the City is in vertical datum NAVD 1988.

Based on the GIS contour data, it appears that lowest adjacent grade to buildings numbered 1-7 are approximately between elevation 317 ft and 321 ft NAVD 1988 (see **Table 4-3**). Since the FEMA FIS water surface elevations and profiles are represented in vertical datum NGVD 1929 the building elevations extracted from the City GIS data were converted to the NGVD 1929 datum. The conversion between these two datums at this location is approximately 0.77 feet (NAVD 1988 + 0.77 ft = NGVD 1929). Since all elevations are approximate, building elevations were rounded to a whole number.

Table 4-3: Mosby Woods Condominiums Approximate Building Elevations

Building No. (See Figure 4-2)	Approximate Elevation ¹ (ft NGVD 1929)
1	321
2	319
3	319
4	317
5	317
6	319
7	320

¹ - Based on estimates of the lowest adjacent graded retrieved from the City's GIS data in NAVD 1988 and converted to NGVD 1929

Water surface elevations for the 10-year, 25-year, 50-year, 100-year and 500-year recurrence events are reported in **Table 4-4** below. These elevations were extracted from the FIS HEC-RAS model. Based on these flood profiles, it appears that no buildings are located within the 10-year floodplain however 5 buildings are located within the 25-year floodplain, and 7 within the year 100-year floodplain.

Table 4-4: Water Surface Elevations at Mosby Woods Condominiums (ft NGVD 1929)

Cross-Section Location	10-Year	25-Year	50-Year	100-Year	500-Year
Immediately Upstream of Stafford Drive Crossing (no. 1162.081)	315.28	318.34	321.23	322.23	324.83
At Mosby Woods 200 ft Downstream of Plantation Parkway (no. 2146.167)	318.27	319.86	321.83	322.66	325.18

As discussed in Section 2.6, it is estimated that Hurricane Sandy (2012) is between a 10-year and 25-year, 24-hour event. Tropical Storm Lee (2011) and closely resemble a 100-year, 12 hour event and the unnamed tropical cyclone (2006) is between a 10-year and 25-year, 24-hour storm event. Tropical Storm Lee and the unnamed tropical cyclone both caused flood damage, as predicted by the FIS flood levels. Hurricane Sandy floodwaters, on the other hand, were observed on the grounds close to, but not entering units; the predicted conditions in the FIS (that flooding would occur) does not match the Hurricane Sandy event conditions. One of the reasons that units were not inundated from Hurricane Sandy flood waters is that residents prepped for the storm using and engaged in floodfighting activities.

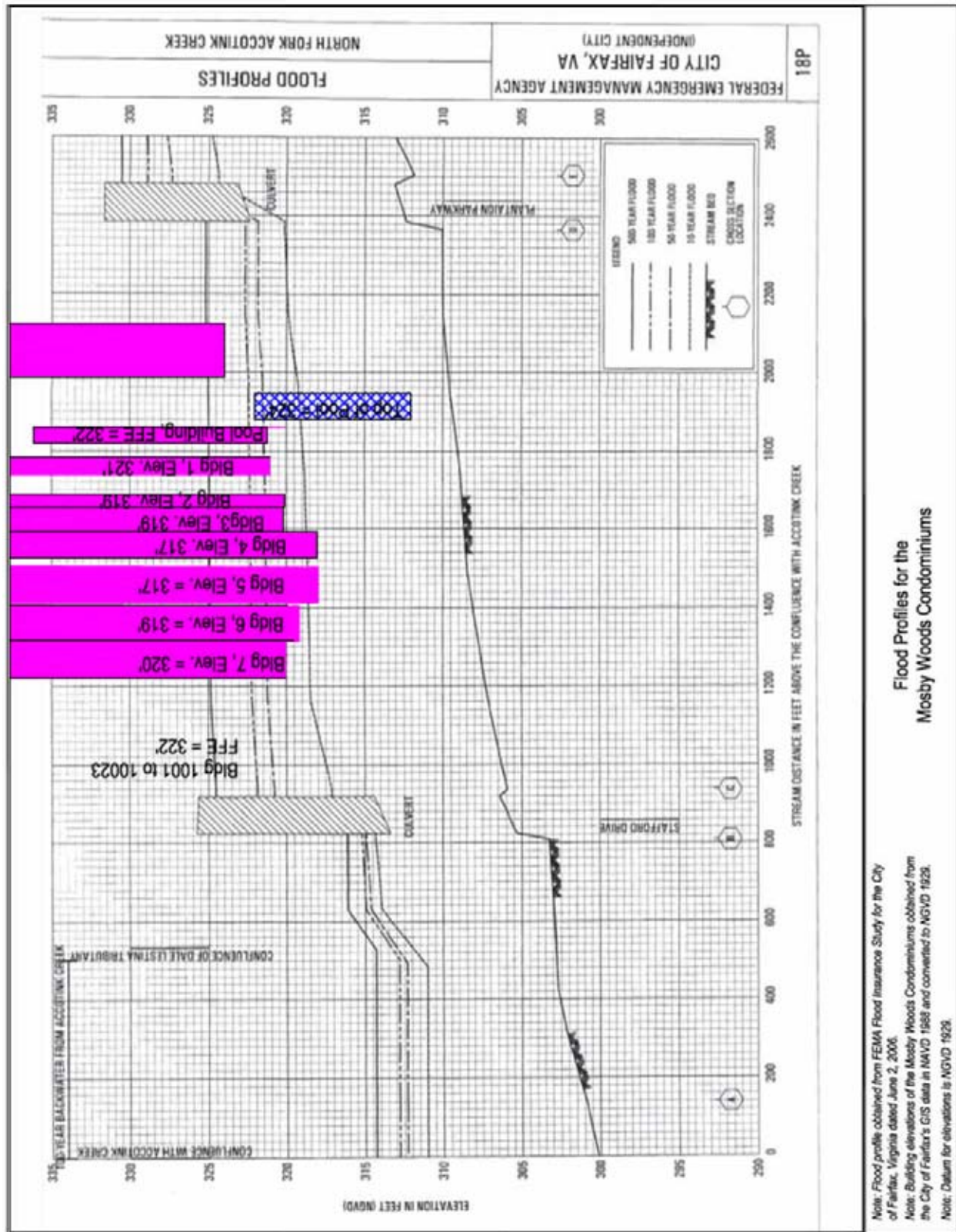


Figure 4-5. FEMA Flood Profile for North Fork Accotink Creek with Mosby Woods Condominium Buildings

The FIS flood profile shown in **Figure 4-5** shows a significant difference in flood elevations directly above and below the culvert located at Stafford Drive, 860 feet above the confluence with Accotink Creek. The elevation of the 500-year flood profile is approximately 324.5ft immediately upstream of the culvert and 316ft immediately downstream of the culvert, a difference of 8.5ft. The 10-year flood profile also has a difference of approximately 2.75ft (from 317ft upstream of the culvert and 314.25ft downstream of the culvert). The difference in water surfaces upstream and downstream of Stafford Drive suggests that the capacity of the culvert is not sufficient for large storm events, causing water to backup and inundate the Mosby Woods community. Increasing the capacity of flow through Stafford Drive may reduce flood levels upstream in the vicinity of the Mosby Woods property.

URS personnel performed field reconnaissance in January 2013 to investigate conditions of the Mosby Woods study area. During this investigation significant erosion was noted along the banks of North Fork Accotink Creek. A resident who has lived at Mosby Woods for over 20 years indicated that the creek has changed from relatively straight to a “horseshoe” shape, as shown in **Figure 4-2**. Pictures of the current state of the creek, as of January 2013, are displayed in **Figure 4-6** and **Figure 4-7**.



Figure 4-6. “Horseshoe” Bend in North Fork Accotink Creek at Mosby Woods Condominiums



Figure 4-7. Fallen Tree Due to Heavy Bank Erosion at Mosby Woods Condominiums

4.5 Alternatives Analysis

A wide variety of management measures were evaluated that would address the planning objectives of for the Mosby Woods Condominium study area. Alternative plans were then developed which comprised of one or more of the management measures. The alternatives went through an initial screening that used the following criteria: effectiveness, environmental considerations, stakeholder impacts, and cost effectiveness. Each of these criteria is previously defined in Section 2.3. ROM costs were developed for each plan and potential funding opportunities were evaluated. The initial screening resulted in three alternative plan design concepts being carried forward in this analysis.

The study analyzed a number of possible types of measures and alternative plans that could reduce the flood risk at the Mosby Woods Condominiums. These measures and plans include structural measures and non-structural measures (previously defined in Section 3.5), as well as increasing conveyance and flood storage. The measures that were considered in this study for Mosby Woods are:

- Non-Structural
 - Flood-proofing structures in the floodplain
 - Acquisition of flood-prone structures
 - Elevating structures in floodplain
- Structural
 - Levee or berm system along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive

- Flood wall along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive
- Increase conveyance
 - Dredging and Stream Restoration of North Fork Accotink Creek between Plantation Parkway and Stafford Drive
 - Increase conveyance through Stafford Road culvert crossing
- Increase Flood Storage
 - Increase on-line flood storage in North Fork Accotink Creek floodplain between Plantation Parkway and Stafford Road
 - Increase the flood storage upstream of Plantation Parkway with a dam in-line with the North Fork Accotink Creek

Each of the potential flood mitigation measures listed above were preliminary screened and either further evaluated or eliminated from further consideration. Refer to **Table 4-5** presenting a description and preliminary screening analysis for each potential measure. The top two plans were further evaluated as part of an alternative analysis which is described in the later sections of this report. Similar to the Foxcroft Colony study, a baseline on to which to measure any proposed alternative is considered to be the current conditions or “no action alternative.”

Table 4-5: Flood Mitigation Measures Screening Matrix for Mosby Woods Condominiums

Alternative Measure /Plan Name	Alternative Type	Description	Analysis	Furthered Considered?
Flood-proofing structures in the floodplain	Non-Structural	Install flood-proofing measures on condominium buildings to prevent floodwater from entering structures.	Flood-proofing is often an economical measure to reduce flood risk, however, flood-proofing structures is not suggested when floodwaters are greater than 3 feet. At Mosby Woods 5 of the 7 buildings in the 100-year floodplain exceed the recommended 3-foot flood depth. While this measure is not suggested for floodwaters exceeding 3 feet, flood-proofing may be feasibly to reduce flood risk for events less than the 100-year and therefore, is further considered as an alternative plan in this analysis.	Yes
Acquisition of flood-prone structures	Non-Structural	Acquire flood prone structures located in the floodplain.	With acquisition the flood-prone area is returned back to a natural floodplain. This would require at least 7 buildings be acquired. It is unlikely that his measure would be cost effective.	No
Levee/berm along the North Fork Accotink Creek	Structural	Install a 1,200 foot earthen levee/berm system from downstream of Plantation Parkway to Stafford Drive with a top elevation between 323 ft and 324 ft, 1 foot about the 100-year floodplain water surface elevation.	This measure will protect Mosby Woods condominiums from flood events up to and including the 100-year event. Interior drainage must be removed by a pump station. A drawback to a levee is the amount of property space required. Generally levees are at a slope of 1V:2H of 1V:3H with a 10 foot wide top. Another consideration to this plan is that a pump station is very expensive. Based on GIS data provided, the height of the levee must be approximately 7-8 feet at its tallest point. There appears to be area to between the condominium buildings and the creek to for a levee. Since there appears to be sufficient space for a levee, this measure is further considered in the alternative analysis.	Yes
Flood Wall along the North Fork Accotink Creek	Structural	Install a 1,200 ft floodwall from downstream of Plantation Parkway to Stafford road at with a top elevation between 323 ft and 324 ft, 1 foot about the 100-year	Similar to a levee, this measure will protect Mosby Woods condominiums from flood events up to and including the 100-year event. Interior drainage must be pumped. A floodwall has a much smaller footprint than a levee however is typically more expensive to	No

Table 4-5: Flood Mitigation Measures Screening Matrix for Mosby Woods Condominiums

Alternative Measure /Plan Name	Alternative Type	Description	Analysis	Furthered Considered?
		floodplain water surface elevation.	construct. Since there appears to be sufficient room at Mosby Woods to construct a levee, and since a floodwall is typically more expensive, this alternative was eliminated from further consideration. Another reason the floodwall was eliminated from further consideration is that during the stakeholder meeting with Mosby Woods Board of Directors, residents suggested that they favored the look of a levee over a floodwall indicating that is ties into the natural surrounds more than a concrete floodwall.	
Dredge and Stream Restoration of North Fork Accotink Creek	Increase Conveyance	Dredge a portion of the North Fork Accotink Creek and install stream restoration techniques to the creek between Plantation Parkway and Stafford Drive	It appears that the North Fork Accotink Creek between Plantation Parkway and Stafford Drive has changed over the past 20 years. Sediment deposition is present and stream banks are eroding. There are several exposed tree roots and downed trees. It is possible that sediment deposition and change in the channel's path has reduced conveyance. It is anticipated that dredging the creek will not have significant impact to increase flood storage volume. Stream restoration activates will promote a healthier stream and reduced bank erosion. This alterative has potential impacts to the environment and wetlands. Ongoing dredging and debris removal maintenance will likely be required. It is unlikely that this alternative plan will alleviate flooding during larger storm events and therefore was eliminated from further analysis.	No
Increase conveyance through Stafford Road culvert crossing	Increase Conveyance	Increase the capacity of flow through Stafford Drive by enlarging/expanding the culvert system	Based on the FEMA FIS, Stafford Drive appears to cause a backup of floodwaters during the 10-year and larger events. There is approximately a 7 feet elevation difference during the 100-year event between upstream and downstream water surfaces. Increasing the capacity of flow through Stafford Drive may alleviate flooding by reducing the water surface	No

Table 4-5: Flood Mitigation Measures Screening Matrix for Mosby Woods Condominiums

Alternative Measure /Plan Name	Alternative Type	Description	Analysis	Furthered Considered?
			elevation upstream of the crossing however the current double box culvert system must be doubled in capacity to achieve a reduction in the floodplain elevations to remove Mosby Woods' buildings from the floodplain. It is anticipated that there are significant costs associated with modifying Stafford Drive crossing from a double box culvert to a bridge to achieve this capacity requirements and therefore this measure was eliminated from further consideration.	
Increase the on-line flood storage in North Fork Accotink Creek floodplain	Increase Storage	Excavate to enlarge the floodplain storage between Plantation Parkway and Stafford Drive.	There is limited area available for excavation in the vicinity of Mosby Woods. It is anticipated that on-line storage would have minimal effect on water surface elevations during large events and therefore this alternative was eliminated.	No
Increase the flood storage with a dam in North Fork Accotink Creek floodplain	Increase Storage	Construct a flood storage dam on the North Fork Accotink Creek upstream of Plantation Parkway.	It is anticipated that a flood storage measure, such as a dam, upstream of Plantation Parkway will not significantly reduce water surface elevations downstream in the vicinity of Mosby Woods. To achieve significant elevation decreases, it is likely that a very large flood control reservoir would be required however environmental impacts, significant property acquisition requirements and high implementation costs would be required for this alternative; therefore it was not considered further.	No

4.5.1 Alternative Plan 1: Flood-proofing Foxcroft Colony Condominium Buildings

Proposed Alternative Plan 1 includes the measure of flood-proofing the buildings of Mosby Woods within the designated floodplain. Based on the effective FEMA FIRM, there are 18 first-floor condominium units in 7 buildings located in the 100-year floodplain. Refer to **Figure 4-8** for proposed flood-proofed buildings (outlined in magenta). During past flood events flood waters have entered these units through the unit's front doors, garden patio doors, windows and the common utility room doors, photos of typical entry points are provided in **Figure 4-9**. Floodwater has then traveled from units through interior walls to adjacent units on the first floor.



Figure 4-8. Mosby Woods Condominiums Buildings to be Flood-proofed



Figure 4-9. Mosby Woods Condominium Building Flood Entry Points

As mentioned previously in Section 3.5, the concept of flood-proofing typically involves sealing the exterior building wall with waterproofing compounds, impermeable sheeting, or other material and using shields for covering and protecting openings from floodwaters. Shields can be used on doors, windows, vents, and other openings. For this concept plan, a water proof membrane and protective covering would be applied to the exterior of the existing walls with the addition of flood barriers at the patio doors and windows and a water tight door at each building's common room entry door. Each of the buildings outlined in **Figure 4-8** are located within the 100-year floodplain and therefore are recommended for flood-proofing measures.

Generally, walls should not be flood-proofed above a height of approximately three feet, due to the danger of structural failure from hydrostatic forces, unless a structural engineer has confirmed that the building is designed to handle the forces. The lowest building elevations (Buildings 4 and 5) are around elevation 317 ft based on estimates of the lowest adjacent graded retrieved from the City's GIS data. The 1% annual change base flood elevation is approximately 322 feet at Mosby Woods which relates to approximately 5 feet of flooding during a 100-year event. For Mosby Woods, where the 100-year flood depths exceed the 3-foot flood-proofing suggestion, buildings may still be flood-proofed up to 3-feet however will not be protected from flood waters that exceed this 3-foot depth. This will aid in reducing flood risk to residents in the floodplain during the 25-year frequency event.

This plan was screened with the flowing criteria as described below: effectiveness, environmental considerations, stakeholder impacts and cost effectiveness. Funding opportunities and ROM costs were also evaluated.

4.5.1.1 Effectiveness

This plan involves sealing the structure to keep floodwaters out and to keep the structure dry below the flood protection elevation. Closure structures placed across all openings must be closed manually prior to a flood to be effective. Similar to that proposed with Foxcroft Colony, the advantages and disadvantages of flood-proofing are summarized in **Table 4-6** below.

Table 4-6: Alternative Plan 1 Operational Advantages and Disadvantages¹

Advantages	Disadvantages
<ul style="list-style-type: none"> • Dry flood-proofing is less costly than other retrofitting methods. • Does not require the additional land that may be needed for levees and floodwalls. • Easy to construct/install. • Often can be installed before other flood reduction measures such as levees and construction projects. 	<ul style="list-style-type: none"> • Dry flood-proofing requires human intervention and adequate warning to install protective measures. • Does <u>not</u> minimize the potential damage from high-velocity flood flow and wave action. • Does not protect grounds and surrounding areas outside of building. • Ongoing maintenance is required. • Flood shield may not be aesthetically pleasing.

¹ FEMA 312, *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding*

A disadvantage to this plan is that it relies on manual operation to lift the closure shields on the doors and windows of each building. Property owners or onsite maintenance workers must be able to install

flood shields and physically perform the activities required or the successful operation of the dry flood-proofing before the floodwaters arrive. While dry flood-proofing require maintenance it is limited to cleaning and inspecting for leaking.

Flood-proofing would be designed to protect to an elevation of the 3 feet above the building elevation. Based on estimates to the lowest adjacent grade next to each building it appears that all buildings would be protected from the 25-year frequency event, 4 buildings from the 50-year event, and 4 buildings from the 100-year event (refer to **Table 4-7**). It should be noted that all elevations provided in this analysis are approximate and a more detailed elevation using surveyed finished flood elevations is necessary to determine actual flood risk reduction.

Table 4-7: Buildings Protected by Dry Flood-proofing for Various Frequency Events

Building No.	Building Elevation ¹ (ft NGVD 1929)	Elevation of Proposed Flood-proofing (ft NGVD 1929)	Building Flood-proofed to 1% chance (100-year) (~322 ft NGVD 1929)	Building Flood-proofed to 2% chance (50-year) (~321.5 ft NGVD 1929)	Building Flood-proofed to 4% chance (25-year) (~319-320 ft NGVD 1929)
1	321	324	Yes	Yes	Yes
2	319	322	Yes	Yes	Yes
3	319	321	No	No	Yes
4	317	320	No	No	Yes
5	317	320	No	No	Yes
6	319	322	Yes	Yes	Yes
7	320	323	Yes	Yes	Yes

1 – Building elevations are approximate, based on estimates of the lowest adjacent graded retrieved from the City's GIS data.

4.5.1.2 Initial Hydrology and Hydraulic Analysis

The proposed non-structural measure of flood-proofing does not alter the current hydrology or hydraulics of the study area therefore no analysis was conducted.

4.5.1.3 Environmental Considerations and Permitting

It is anticipated that this alternative measure will not have any direct or indirect negative impacts to the environment. It is not anticipated that any environmental permits are needed for implementing this measure.

4.5.1.4 Stakeholder Impacts

Stakeholders directly impacted by this plan include Mosby Woods residents located on the first floor of buildings in the floodplain. Other stakeholders, including Mosby Woods residents not located in the floodplain and other nearby residents upstream and downstream of the condominium property are not impacted by this plan.

During an initial meeting with the Mosby Woods Condominium Association on February 5, 2013 flood-proofing building structures at Mosby Woods was with the Mosby Woods Home Owner's Association and T&W Management Group, the condominium's management agent. A general consensus of the

Mosby Woods residents at this meeting were that they were not in favor of flood-proofing buildings as a measure to reduce flood risk to their community. Opinions of representative residents at this meeting felt that flood-proofing the buildings would not solve their problems with flooding community grounds even if the buildings were protected and that they wanted a more permanent solution to flooding, even if construction of such a solution is years out.

4.5.1.5 Rough Order Magnitude Cost Estimate

To estimate the costs associated with closure gates on doors and windows, several manufactures' costs were evaluated. Relative costs associated with this alternative plan are provided in rough order of magnitude in **Table 4-8**. Based on the limited scope of this Analysis, the project costs provided may vary depending on design elements not reviewed with this study. ROM Costs for this Alternative Plan are approximately \$65,000.

Table 4-8: ROM Costs for Dry Flood-proofing Mosby Woods Buildings

Dry Flood-proofing Measure	Number of Units	Measure	Unit Cost	Cost
Waterproofing with a polyethylene sheet and covering with a facing material such as brick (3 feet high)	2460	LF	\$13.50	\$33,200
Caulking/sealant – high performance electrometric “urethane” sealant (around door and window openings)	730	LF	\$2.50	\$1,800
Closure Barrier, 3 foot for windows below elev. 322 ft.	28	Each	\$550	\$15,400
Closure Barrier, 6 foot for patio doors/windows	28	Each	\$1,200	\$33,600
Closure Door, unity door water tight	4	Each	\$1,000	\$4,000
Engineering Design	1	Unit	\$22,000	\$22,000
Contingency (misc.)	1	Unit	\$15,000	\$15,000
Total ROM Costs				\$125,000

4.5.1.6 Cost Effectiveness

Based on the combination of the estimated cost of the project and the likelihood of effectiveness, a related cost effectiveness ranking of moderate assigned.

4.5.1.7 Grant and Funding Opportunities

Dry flood-proofing residential structures do not qualify for funding support under the FEMA HMA program. It should also be noted that there is no credit or reduction in flood insurance premiums for flood-proofed residential structures.

4.5.2 Alternative Plan 2: Install Earthen Levee/Berm and Pump Station

Proposed Alternative Plan 2 includes installing an earthen levee / berm along the North Fork Accotink Creek (refer to **Figure 4-10**). The top elevation of the levee will be set to an elevation between 323 ft to 324 ft, approximately 1 foot above the 100-year BFE in this area. As part of this plan the interior drainage would have to be pumped by a pump station. The stormwater and sanitary sewer systems would be modified to prevent the backflow of the flood waters.

The levee will act as a barrier protecting the area behind the wall from flooding during the 100-year and lesser events. Typically, earthen levees are constructed of compacted fill taken from locally available impervious soils. When constructing a levee near buildings, pumps must be incorporated to provide proper drainage from groundwater seeping under the levee and rainwater from the building side of the protection. During a flood, the storm drains pipes that usually take rain water from the community to the creek are closed so that the flood water from the creek does not back up and flood the community. Typically, a large pump station is needed during a flood to pump the rain water that is trapped on the land side of the levees over the levees to the river side. The pump also pumps any water that seeps under the levee over the river side. One potential drawback to a levee is the amount of property space required. To minimize erosion and to provide stability, embankment slopes must be fairly gentle, usually at a ratio of one vertical to two or three horizontal. An example of a typical levee cross-section is provided in **Figure 4-11**.

The grade along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive varies. Based on the 100-year base water surface elevation between 322 ft and 323 ft, the proposed levee will tie into elevation 323 ft near Stafford Drive and 324 ft at the upstream point, 1 foot above the 100-year elevation. To meet FEMA certification requirements for a levee the top of levee must be designed to an elevation 3.5 feet above the 100-year elevation which is between elevation 325.5 and 326.5 ft NGVD 1929. To meet a tie in elevation of 325.5 ft at the downstream point of the levee near Stafford Drive, additional measures would need to be taken to elevate Stafford Drive as it appears that the top elevation of the roadway at the North Fork Accotink Creek crossing is approximately at elevation 324 ft on the northern side of the channel where the levee is proposed. Alternatively the tie-in elevation may be lowered and not meet FEMA's freeboard requirement. Since it appears that there is not sufficient elevation to meet FEMA's freeboard requirements the levee concept design is based on a 1 foot freeboard.

As part of this plan the interior drainage would have to be modified and a pump station with emergency power would be installed. The stormwater and sanitary sewer systems would be modified to prevent the backflow of the flood waters. A pump station is proposed to pump interior drainage from the Mosby Woods community grounds collected behind the levee. It is recommended that the pump shall be sized to have enough capacity to drain a 100-year frequency event from behind the levee.

Since the levee is proposed at an elevation one foot above the 100-year BFE, the proposed design would not meet FEMA certification requirements and the Mosby Woods residents in the floodplain would still be required to purchase flood insurance.

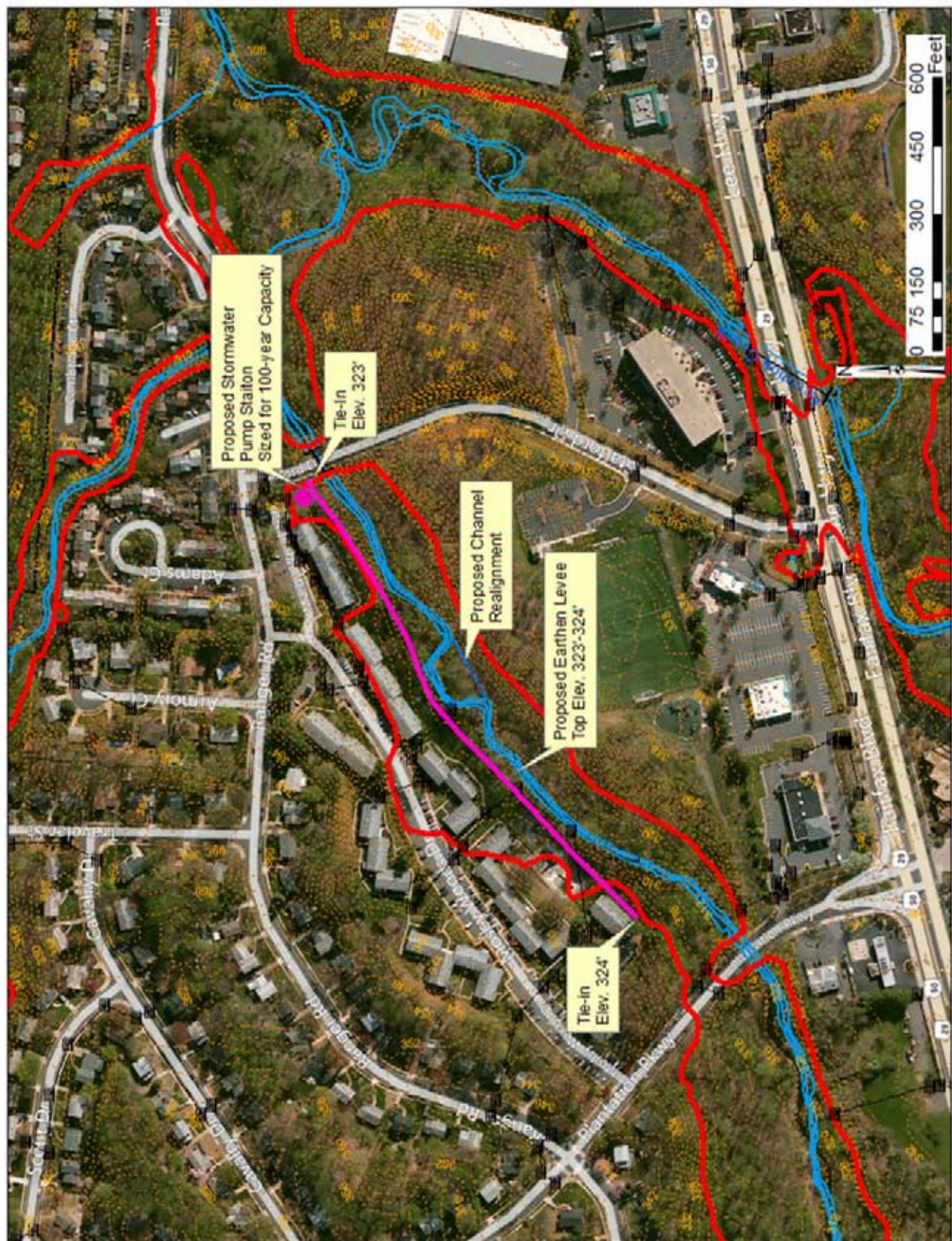


Figure 4-10. Proposed Conception Plan – Alternative Plan 2 Levee and Pump Station

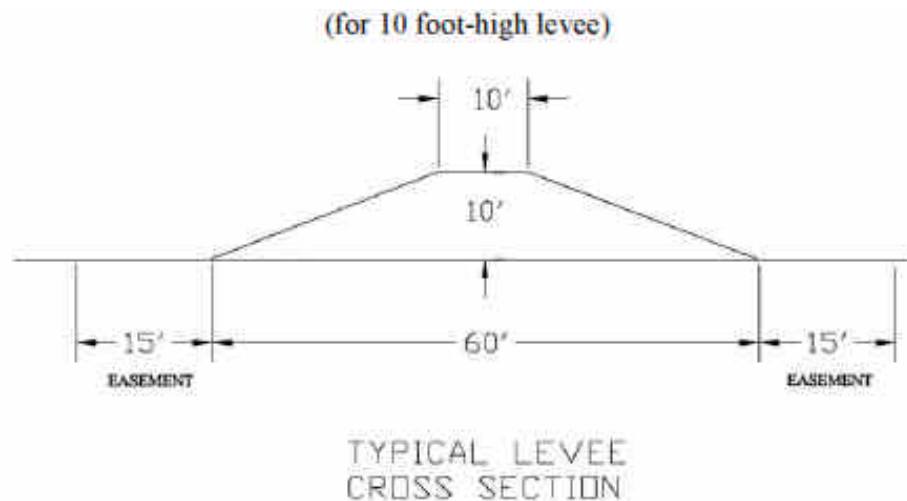


Figure 4-11. Typical Levee Cross-Section

4.5.2.1 Effectiveness

This alternative plan is an effective solution allowing reduced flooding during, and less than, the 100 year event. An earthen levee is a permanent structural measure that requires maintenance to be effective. The pump station, similarly, requires maintenance to remain effective. Flood risk is reduced with this plan since the community is protected from the 100-year event and the surrounding areas will not experience an increase in flooding due to the proposed levee. However, O&M requirements are high for both the levee and pump station requiring frequent inspections and periodic maintenance. The advantages and disadvantages of this plan are summarized in **Table 4-9** below.

Table 4-9: Alternative Plan 2 Operational Advantages and Disadvantages

Advantages	Disadvantages
<ul style="list-style-type: none"> Does not require continuous human intervention during a flood event such as flood-proofing methods. Helps protect community from the 100-year flood event. 	<ul style="list-style-type: none"> May have direct impacts to the environment. Is costly to construct. Will take several years to implement between design and construction. Requires periodic maintenance and routine inspections.

4.5.2.2 Initial Hydrology and Hydraulic Analysis

A limited hydraulic analysis was conducted for this feasibility analysis to identify water depths and any change in the floodplain for a range of hydrologic events with the proposed levee with a top elevation of 322 ft, the same elevation of the 100-year BFE in this area, in effect. It appears that the proposed levee does marginally increase the BFEs of the floodplain as per **Table 4-10**.

A very rough calculation was completed on the interior drainage area of Mosby Woods to confirm that the quantity of stormwater runoff onsite will not flood buildings during the 100-year event. This is based on the assumption that the floodwaters on of North Fork Accotink Creek are at the elevation 322.0 ft on the river-side of the levee and that no runoff from Mosby Woods can drain to the river-side of the levee due to the backup of floodwaters to the BFE elevation. This calculation was computed to determine if a

pump station was needed to handle interior drainage. The information provided in **Table 4-11** was used to calculate the 100-year interior drainage.

Table 4-10: Current vs. Proposed Water Surface Elevations at Mosby Woods Condominiums

	Current/ Proposed	10-Year	25-Year	50-Year	100-Year	500-Year
Immediately Upstream of Stafford Drive Crossing (no. 1162.081)						
	Current	315.28	318.34	321.23	322.23	324.83
	Proposed	315.28	318.34	321.23	322.23	324.88
	Difference in WSE (ft)	0.00	0.00	0.00	0.00	0.00
At Mosby Woods 200 ft Downstream of Plantation Parkway (no. 2146.167)						
	Current	318.27	319.86	321.83	322.66	325.18
	Proposed	318.28	319.96	321.98	322.82	325.37
	Difference in WSE (ft)	0.01	0.10	0.15	0.16	0.19

Note: Elevations reported in NGVD 1929. Current are those WSEs reported in the FIS HEC-RAS model. Proposed is the WSEs estimated with a proposed floodwall at Foxcroft Colony per Alternative Plan 3 conditions.

Table 4-11: Interior Drainage Calculations for Mosby Woods Condominiums

Calculation Measure	Value
Drainage Area	32.4 Acres
Rainfall Intensity (i) for 100-Yr	8.25 in/hr
Rational Method Runoff Coefficient (c.)	0.75 (residential area)
Correction Factor for Ground Saturation (cf)	1.25
Flow Rate (Q) $Q=ciA * cf$	180 cfs

Based on contour elevations behind the proposed levee, an estimate of storage was computed to determine the elevation of stormwater runoff if no pump station was in place and all runoff was stored behind the levee. The corresponding elevation is 329, assuming pump or ditches to convey water which is well above the elevations of the Mosby Woods buildings. Therefore, a pump station is necessary to convey water from behind the levee.

4.5.2.3 Environmental Considerations and Permitting

It is anticipated that this alternative plan will have direct impacts to the environment and the surroundings. It is anticipated that environmental permits from the State or Federal government are needed for implementing this measure. The proposed levee is located within a designed Riparian protection area and requires a permit for construction. It is anticipated that there are wetlands around the creek and a 401/404 Joint Permit Application for Wetlands may be required.

4.5.2.4 Stakeholder Impacts

Residents of Mosby Woods condominiums would be protected from the 100-year flood from the North Fork Accotink Creek with the levee in place. Interior stormwater drainage would be the only impact to residents. Nearby property owners would not be impacted by the proposed alternative plan since it is not anticipated that the water surface elevation will not significantly increase upstream or downstream water surface elevations.

4.5.2.5 Rough Order Magnitude Cost Estimate

Relative costs associated with this alternative plan are provided in rough order of magnitude in **Table 4-12**. Based on the limited scope of this Analysis, the project costs provided may vary depending on design elements not reviewed with this study. ROM costs for this alternative are around \$2.7 million.

Table 4-12: ROM Costs for Levee and Pump Station at Mosby Woods Condominiums

Measure	Number of Units	Measure	Unit Cost	Cost
Earthen Levee (6 ft avg. height with base)	1,200	LF	\$35	\$420,000
Excavation for levee base and pump station	1,300	CY	\$11	\$14,300
Pump station and features	1	Each	\$1,250,000	\$1,250,000
Backflow prevention valve fitted to a 25" culvert, installed	3	Each	\$1,100	\$3,300
Stormwater sewer system reconfiguration	1	Each	\$30,000	\$30,000
Site features (landscaping, etc.)	1	Unit	\$50,000	\$50,000
Lands, Easements, and Rights of Way	1	Unit	\$30,000	\$30,000
Preconstruction Engineering and Design ¹	1	Unit	\$400,000	\$400,000
Construction Management ²	1	Unit	\$200,000	\$200,000
Contingency	1	10%		\$300,000
Total ROM Costs				\$2,640,000

¹ PED is to complete the final design, prepare permit applications and prepare the plans and specifications.

² Construction Management is estimated to be 10% of the project construction cost plus contingency.

4.5.2.6 Grant and Funding Opportunities

Eligible activities that may be funded by FEMA's HMA programs vary by program and mitigation activity. A project of this size including a levee and pump station may be funded by the HMGP program however it must have a BCA high enough to justify Federal support. In order to determine if this plan is eligible, it must be carried to a design level where all project elements and costs are defined. An economic analysis or BCA of potential flood damage reduction benefit in the floodplain will be necessary to determine if this plan would be potentially eligible for funding support. A plan must have a benefit cost ratio greater than one, or net benefit greater than zero, to be justified.

4.5.2.7 Cost Effectiveness

This plan potentially has the highest level of risk reduction from the 100-year flood event when compared to other plans evaluated for this study area. However, due to the costs associated with a levee and pump station to protect the Mosby Woods community, this plan is assigned a moderately low cost effectiveness ranking.

4.6 Recommendations

Two alternative plans are recommended for the Mosby Woods Condominiums which vary in cost and risk mitigation. The recommended plan from the two for the Mosby Woods study area is dependent of the funding available to support the project.

The first plan is to flood-proof the condominium buildings located within the 100-year floodplain. Flood-proofing costs are estimated to be \$125,000. The same advantages and disadvantages apply to this plan

as with flood-proofing the Foxcroft Colony buildings. The main disadvantage is that human intervention is required to set up the flood barriers prior to a flood event. However, if implemented correctly, this plan will reduce the flood risk to Mosby Woods residents located in the floodplain. It should be noted that flood-proofed residents in the floodplain at both Foxcroft Colony and Mosby Woods should continue to purchase flood insurance since flood-proofing is not a FEMA recognized method to remove buildings from the floodplain.

Proposed Alternative Plan 2 for Mosby Woods includes installing an earthen levee / berm along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive and includes a pump station to remove drainage behind the levee. Estimated costs for this alternative plan are approximately \$2.7 million. This plan provides a higher level of flood risk reduction compared to flood-proofing the buildings.

5 Daniels Run

The primary problem identified in the study area is stream erosion along Daniels Run just south of Daniels Run Elementary School. The following section provides information describing the study area location, identifies representative stakeholders, and provides a description on the history of erosion issues and previous stream restoration efforts.

5.1 Location of Study Area

Daniels Run begins east of the intersection of Armstrong Street and George Mason Boulevard and flows in a northeasterly direction for approximately 13,700 lf before emptying into Accotink Creek on Army Navy Country Club property. The portion of the channel that is the subject of this study is located on the property of Daniels Run Elementary School, approximately 750 lf. A map depicting the contributing watershed to this point is presented in **Figure 5-1**. A more detailed base map of the subject reach is presented in **Figure 5-2**.

5.2 Stakeholders

The property boundary depicted in **Figure 5-2** was obtained digitally from the City of Fairfax Geographic Information System (GIS). The section of Daniels Run, that is the subject of this study, is located entirely within the parcel, which is owned by the School Board. In a meeting held with school staff, URS learned that they have been very active in the planning and implementation of restoration measures within the subject reach, in conjunction with the-not-for-profit organization “Lands and Waters.” More information regarding the previous restoration work is provided in Section 5.4 below.

Another stakeholder is the City of Fairfax Parks and Recreation Department (Parks). Greg Tonge (Park Manager) was engaged to discuss erosion issues and wanted to get feedback on how it impacts park users. He stated that the ongoing erosion is a concern for Parks and recognized the magnitude of the problem. He also stated that the Parks use and maintain the open area on the southern side of the channel; and therefore, work on the channel could be an impact.

5.3 History of Stream Erosion

It is a well-accepted and understood principle that changes in land use within a watershed, primarily related to the increase in impervious area resulting from land development, increases stormwater runoff rates and volumes. This increased flow degrades downstream receiving waters that are insufficient in size or do not have appropriate substrate to handle the change in flow regime.

Historically, stormwater management (SWM) practices control the peak flow rate in a pre- versus post-development condition. However, as the amount of impervious area increases, peak flow rate is not the only concern; the volume of runoff also increases as less water is able to infiltrate into the ground. This fact is depicted in **Figure 5-3**.

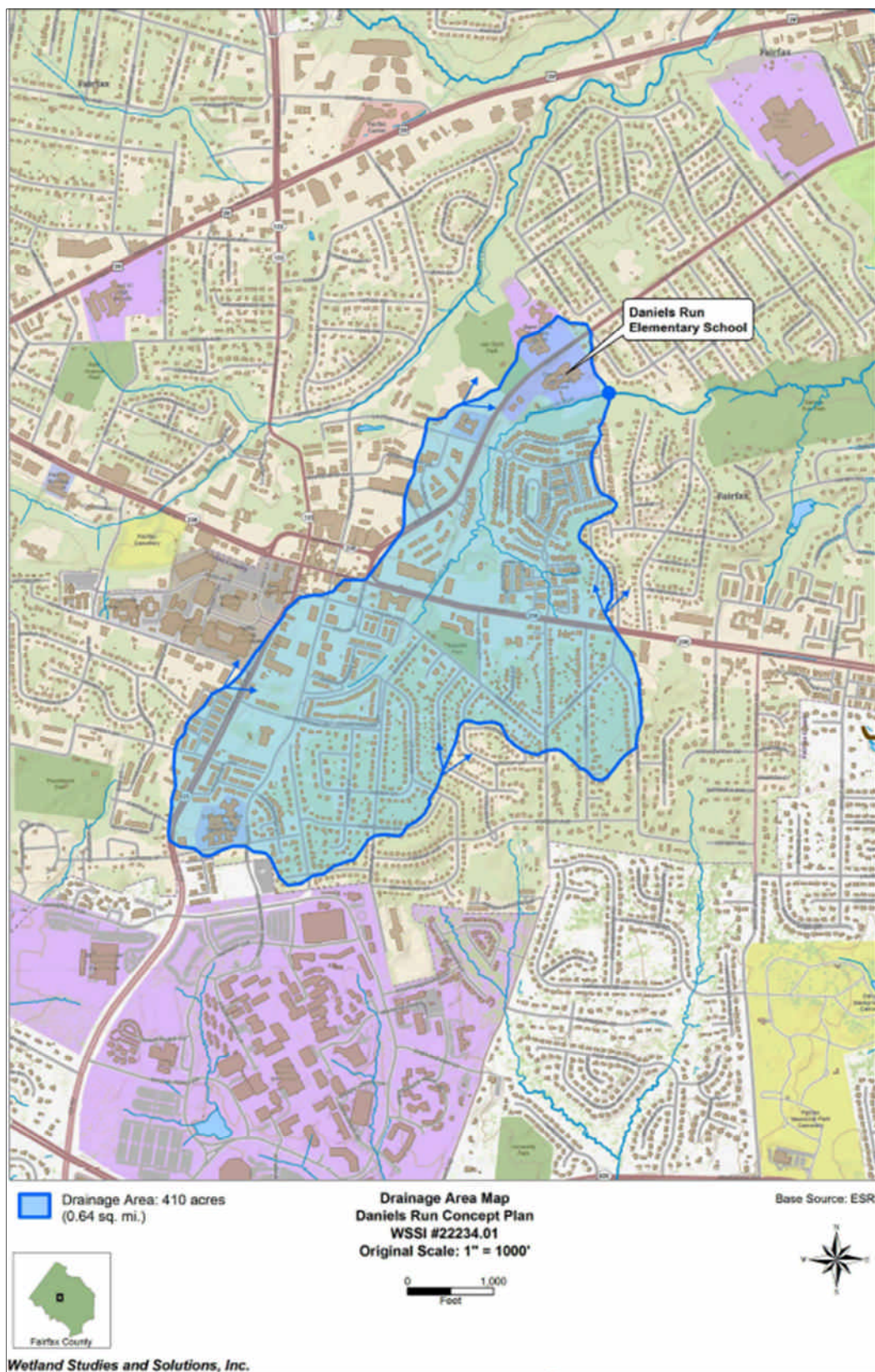


Figure 5-1. Location and Drainage Area Map



Figure 5-2. Daniels Run Elementary School Base Map

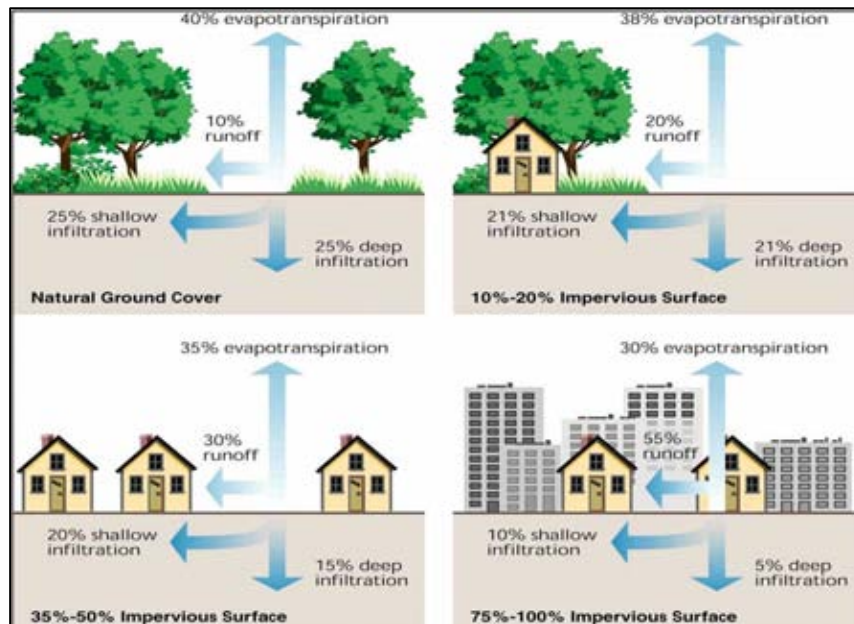


Figure 5-3. Illustration of Water Cycle with Varying Levels of Development

Thus, approximately 3 to 5 times more water runs off of a developed landscape than in the natural state, increasing the peak rate as well as the runoff volume and frequency.

The reasons for the degradation experienced in Daniels Run are obvious when looking at the development of the contributing watershed. The aerial photos in **Figure 5-5a** and **Figure 5-5b** represent the land uses in 1937 and 2012, respectively, in the Daniels Run watershed. While the deforestation evident in the agricultural landscape of 1937 would have also had an adverse impact on the condition of the channel, the impacts caused by the 48% impervious cover seen today are likely many times worse. The result of this impervious cover (and resulting increase in runoff volume) is the degradation of Daniels Run that likely progressed in the fairly predictable manner depicted in the following evolutionary process shown in **Figure 5-4**.

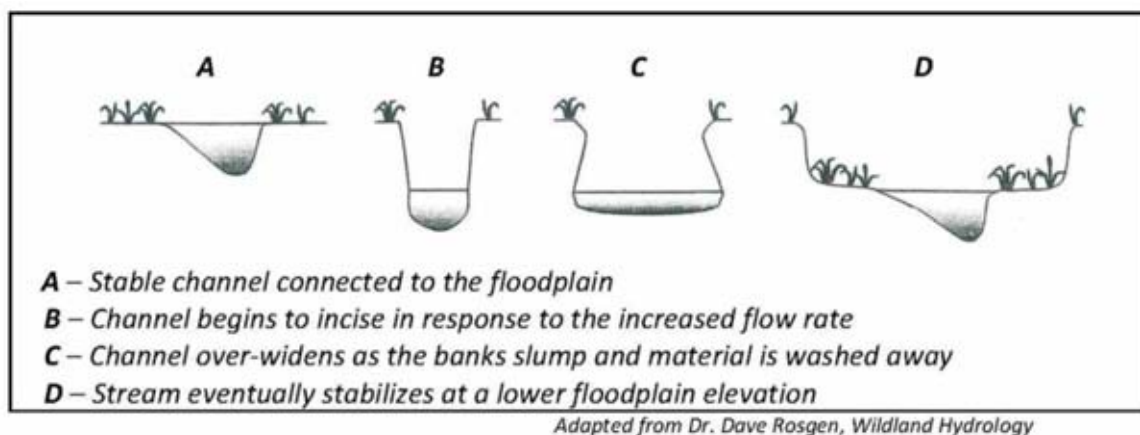


Figure 5-4. Illustration of Stream Degradation over Time



Figure 5-5a. Aerial Photograph of Contributing Watershed in 1937

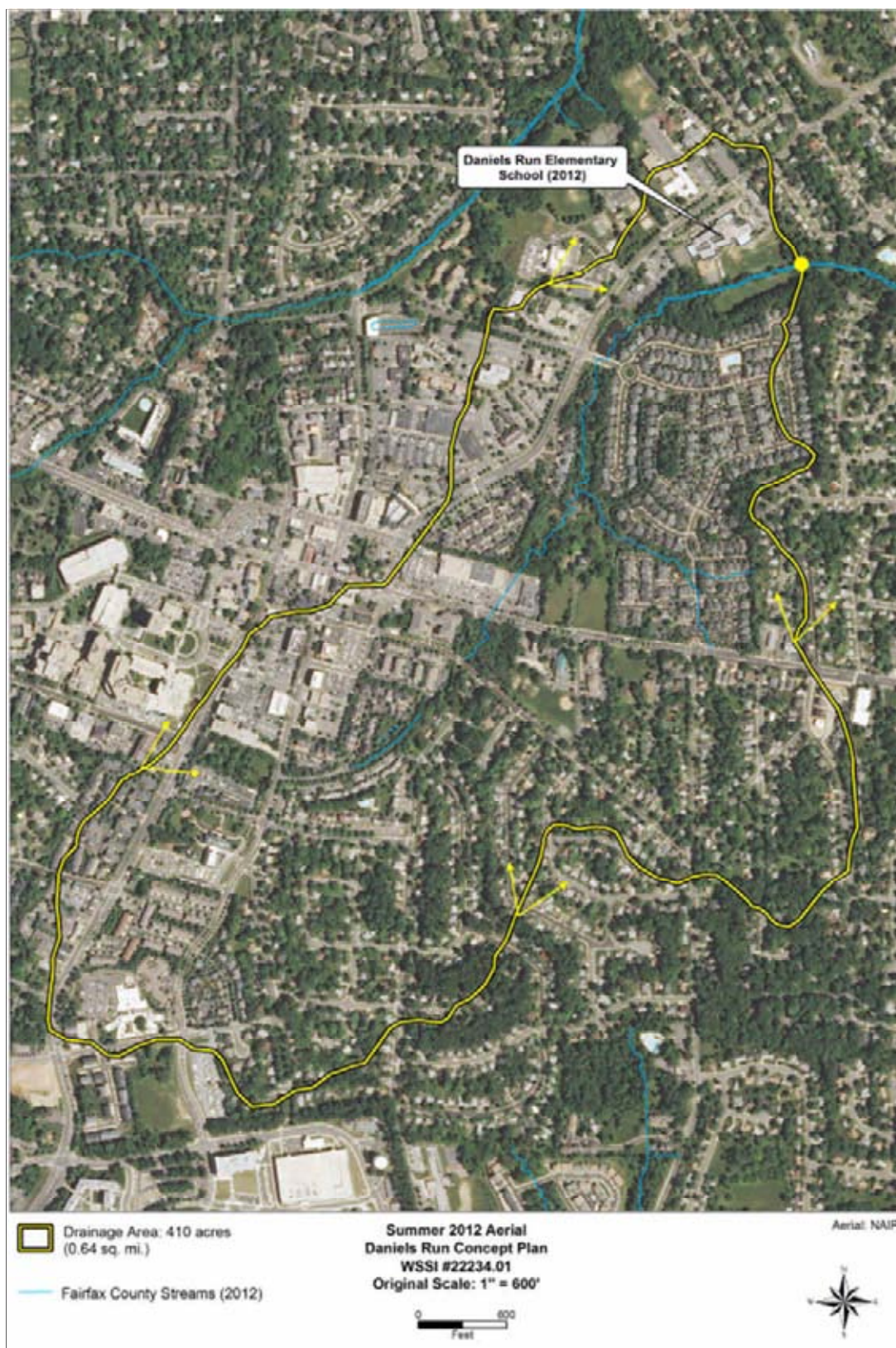


Figure 5-5b. Aerial Photograph of Contributing Watershed in 2012

The subject stream reach is primarily in phase “C” (refer to **Figure 5-4**) and it can take many decades before the channel adjusts to the increased flow rates to the point where stability is returned at a lower elevation (depicted in phase “D”).

Various studies to quantify the flow rates in Daniels Run have been performed over the years. Restoration efforts within the subject reach have also been performed. A discussion of these studies and the previous restoration work is presented below.

5.4 Prior Studies and Previous Restoration Work

5.4.1 Flood Insurance Study

Daniels Run is designated as a FEMA floodplain. As such, detailed hydrologic/hydraulic studies have been performed and are described in the FIS for the City of Fairfax. An excerpt, from the FEMA study depicting the 100-year water surface elevation in the vicinity of the subject reach, is presented in **Figure 5-6** (near cross-section “F”).

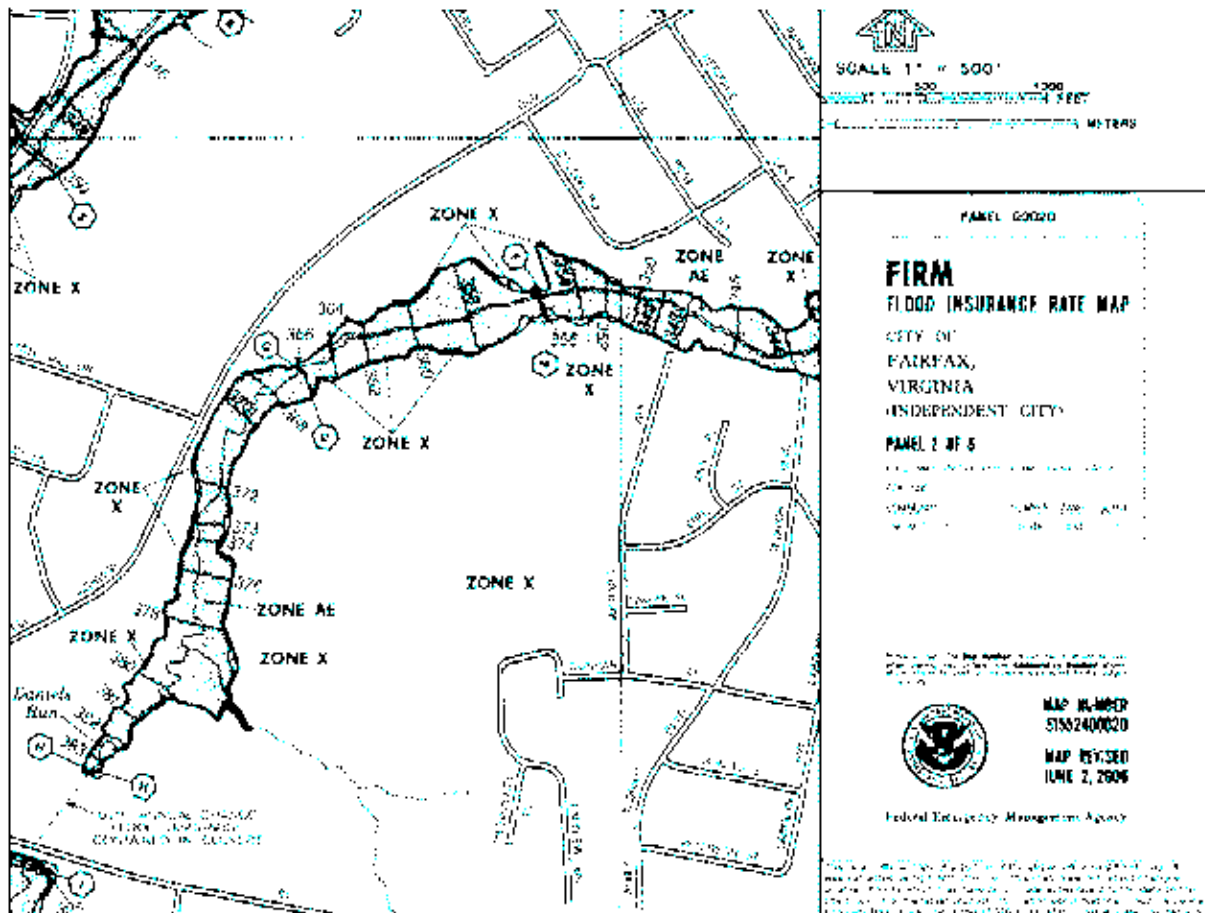


Figure 5-6. FEMA FIRM for Daniels Run Study Area

The hydrologic and hydraulic models and data generated from these studies are available and can provide useful information to assist in developing a stream restoration design. One aspect of particular

importance will be to ensure that any restoration work within the channel will not adversely impact the 100-year water surface elevation.

5.4.2 Army-Navy Country Club Studies

Two studies have been performed by U.S. Fish and Wildlife Service (USFWS) for the Army-Navy Country Club to assess and restore portions of Daniels Run within the Club's property. The portion of Daniels Run that flows through the Country Club is located well below the subject reach.

5.4.3 Farrcroft SWM Facility

Additional information relating to the design of the upstream SWM facility in the community of Farrcroft can provide very useful information as flows in the subject reach are largely controlled by the outlet structure of the facility (location is depicted in **Figure 5-2**). Some of this information has been reviewed for this study, as discussed below.

5.4.4 Filtrexx® Restoration Effort

In July of 2005 and in conjunction with Lands and Waters, Filtrexx® Bank Stabilization Soxx™ were installed along both sides of the channel adjacent to the school property. It does not appear as though any grading was performed and few if any trees were removed during the process.

The theory behind this system is to provide a growing media within the fabric, Soxx™, to facilitate the establishment of vegetative growth. Over time, the roots of the vegetation reinforce and stabilize the eroding banks. However, this "softer" approach is susceptible to damage from storm flows, especially in deeply incised channels with steep banks such as those in the subject reach. In addition, the long-term strength of this system comes from the roots of dense vegetation growing through the Soxx™ and into the underlying stream bank. However, this growth was never achieved, likely due to the shade from the larger trees along the bank. The following progression of photos (**Figure 5-7**) chronicles how the system has degraded over time (the arrow identifies the same tree in each photo).



Figure 5-7. Previous Bank Stabilization Effort

5.5 Current Conditions

As part of this study, a field investigation was performed along Daniels Run from the outlet of the Farrcroft SWM facility down to the Army-Navy Country Club. A photo log of the upper end of Daniels Run, from the SWM facility to the end of the subject reach, is available in **Appendix C3**. From the inspection, the channel is significantly degraded and unstable from the SWM facility through the school

property. The channel is also unstable throughout many portions of the inspected section downstream of the school. There is also significant sediment load as a result of the bank erosion that has exposed a layer of larger material that becomes mobilized as the bank retreats. This fact will have to be considered in the design process (discussed below).

Much of the previous restoration effort has failed as a result of the significant stress on the channel banks and lack of vegetative cover. This is not unexpected as these “softer” approaches often fail in urban environments when the stresses on the banks have not been reduced (through grading and/or raising the stream channel, as discussed below) and existing shade prevents the establishment of the beneficial and necessary vegetation.

The degradation of the stream banks will likely continue until a sufficiently large cross-section has been established. It does not appear as though significant further incision (or lowering of the stream bed) is likely as bedrock was evident in some areas. There is also a significant supply of sediment from upstream bank erosion which helps armor the channel bed.

Note that there are some places within the subject reach where the cross-section is relatively stable, at least along one bank (an example can be seen in **Figure 5-8**). Areas like this may not need to be impacted as part of any restoration effort. However, vertical and/or eroding banks would need to be corrected in order to achieve a permanent and ecologically sustainable restoration.



Figure 5-8. Photograph from Field Investigation

5.6 Alternatives Analysis

There are various restoration methods that can be employed to restore and stabilize degraded urban channels. In general terms, these methods can be grouped as those that provide a means to reconnect the incised channel with its floodplain, and those that basically stabilize the channel in place. A general description of each of these alternatives is provided below, followed by more specific recommendations for the subject reach.

5.6.1 Floodplain Reconnection

Healthy, stable stream systems are hydrologically connected to their adjacent floodplain, overtopping their banks on approximately an annual basis (i.e. during a statistical 1-year storm event). This can be achieved by raising the streambed that has lowered, as depicted below.

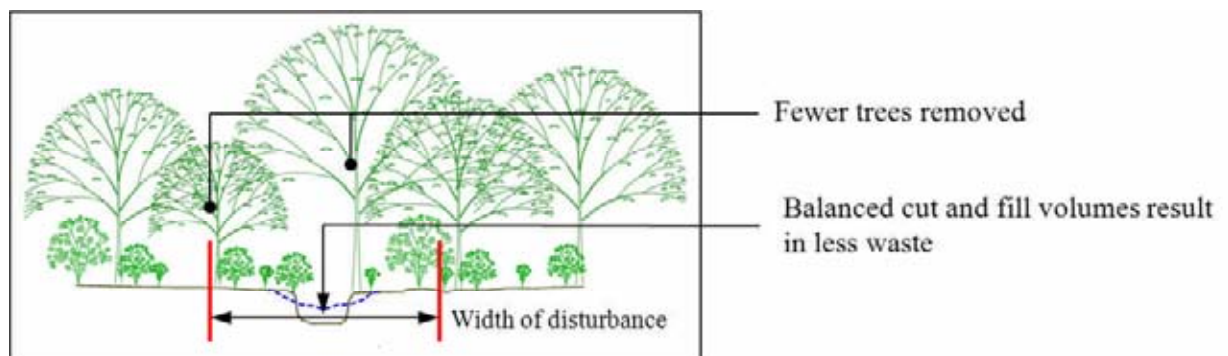


Figure 5-9. Raising Stream Bed

However, this method is not feasible when restoring a relatively short section with incised channels located upstream and downstream of the area to be raised. This is the case with the subject reach.

Another alternative is to excavate a small floodplain at the lower, incised elevation in order to provide some additional cross-sectional area for larger storm events.

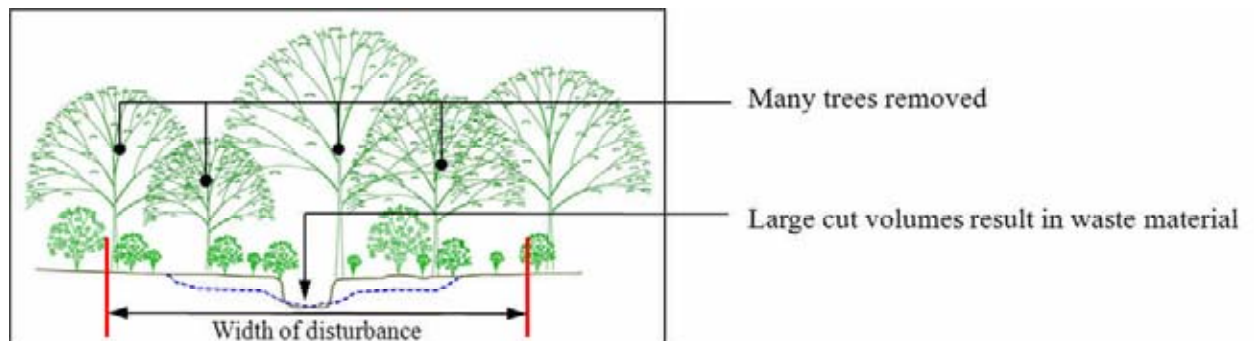


Figure 5-10. Excavation of Small Floodplain

The issue with this method is the increased width of necessary disturbance. This results in increased tree impacts and the potential for impacts to adjacent infrastructure (utilities, trails, fences, etc.). There is also a school project located along the north stream bank (see **Figure 5-2**) that was designed to

promote infiltration and vegetation growth. There is a strong interest from the school staff to protect this area.

5.6.2 Stabilization in Place

This approach can limit the extent of the restoration impact, but does not address all project objectives. While the channel can be “armored” to withstand the extreme flow rates, it does not provide the same floodplain connection as the alternatives discussed above, and thus, does not improve the environmental condition of the channel and adjacent riparian area.

Types of measures can include “softer” approaches, such as the Filtrexx® system that has not been effective given the hydraulic forces in the subject reach. Thus, more substantial, “harder,” methods would need to be employed in order to provide for a permanent repair. This can include the use of imbricated rock walls, as depicted in **Figure 5-11**.



Figure 5-11. Stabilization in Place using an Imbricated Rock Wall

Prior to final selection of any particular restoration approach, it would be necessary to collect additional data – specifically a detailed topographic survey, tree survey, and utility survey would have to be performed. However, the currently available information and assessments performed as part of this study enabled the suggestion of some feasible restoration alternatives.

As discussed in previous sections, the alternatives that meet the most objectives are those that provide long-term stability and provide some degree of floodplain reconnection that will enhance the stream and riparian environment. As such, those alternatives include measures to provide a more stable cross-section through grading of the stream banks. More details are provided below.

5.6.3 Alternative Plan 1 - Bank Grading, 3:1 Side Slope

The primary instability within the existing channel is the raw, vertical banks that cannot be sustained and do not allow the establishment of beneficial riparian vegetation; therefore, **Alternative Plan 1 – Bank Grading, 3:1 Side Slope** represents the smallest footprint and consists of grading back the vertical banks at a more reasonable 3:1 side slope (3-ft horizontal for each foot in the vertical direction – so a 4-

ft deep bank would be graded back 12-ft). A graphical depiction in **Figure 5-12**, is based on one of the surveyed cross-sections obtained from the hydraulic model developed as part of the FEMA study.

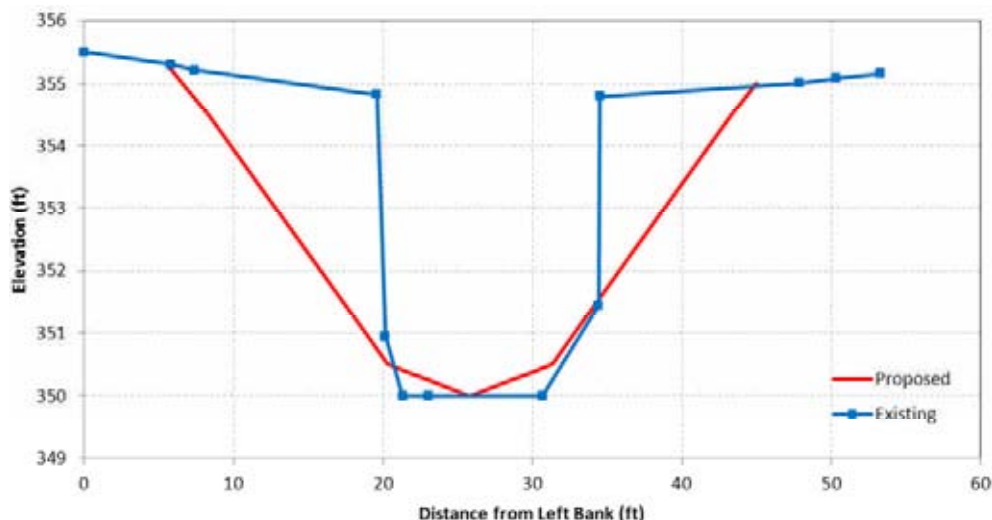


Figure 5-12. Conceptual Cross-Section of Bank Grading, 3:1 Side Slope

Grading back the banks in this manner would require existing trees to be removed and would be followed by the planting of a diverse palette of native trees, shrubs, and herbaceous materials. However, it does not appear as though this would have to be performed along the entire length on both sides of the subject reach. There are some areas that appear to be relatively stable. However, exactly where the grading would be required cannot be determined without the detailed survey information, analysis of the design flow rates, and a stability assessment of the existing and proposed channels. Some relocation of existing trails and fences will likely be necessary.

While this option represents the smallest potential area of impact, it does not represent the largest potential environmental benefit.

5.6.4 Alternative Plan 2 - Bank Grading to Include a Bankfull Bench

Alternative Plan 2 – Bank Grading to Include a Bankfull Bench is similar to the first option, but also includes a smaller channel size to contain the design, “bankfull” flow rate, roughly the 1-year storm event (this was determined using a methodology developed by WSSI), but would have to be confirmed with a more detailed analysis in the design phase. Flows exceeding this bankfull flow rate would have access to a small floodplain bench excavated in the existing banks. Overall, this alternative would result in a larger cross-sectional area than the first alternative, thereby reducing the amount of stress on the channel bed and banks. This would provide a better opportunity for establishment of a stable, diverse riparian corridor. It would, however, require a larger (wider) footprint that will likely impact additional trees and adjacent infrastructure. A conceptual cross-section of this alternative is presented in **Figure 5-13**.

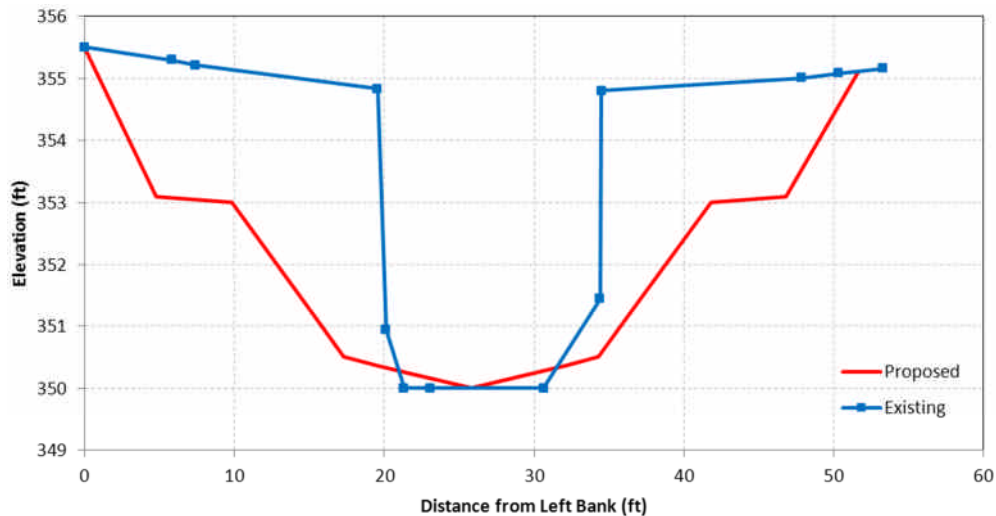


Figure 5-13. Conceptual Cross-Section of Bank Grading to Include Bankfull Bench, 3:1 Side Slope

As with the first alternative, this practice may not be required along the entire length of the subject reach. Exactly where this would be applied will have to be confirmed by the collection of detailed survey data. Relocation of fencing and trails would likely have to occur in some locations. Heavy planting densities of native trees, shrubs, and herbaceous materials would also be applied in this alternative after grading is completed.

5.7 Recommendations

Stabilizing the eroding channel in place with “harder” materials is not a recommended alternative because it does not meet as many of the project objectives as the grading alternatives. While it would provide permanent stabilization of the subject reach, it would result in the loss of existing trees, would be more expensive than bank grading (due to the cost of rocks) and would not be as aesthetically-pleasing or environmentally-beneficial as the grading options. Steep banks would also still exist, representing a safety concern.

The grading of the channel banks proposed in the above alternatives is the recommended solution.

Alternative Plan 2 (with the larger cross-section and a small floodplain bench) would likely result in the most stable, environmentally-beneficial and aesthetically-pleasing restoration. Some areas may be wide enough such that the restored cross-section can be constructed within the existing footprint. The results of a detailed survey, input from the project stakeholders, and a detailed channel analysis will determine the extent to which bank grading can and should be performed.

Further analysis will also include a review of which trees are recommended for removal as part of the restoration. The decision to save or remove trees is often difficult, especially when they may not currently represent a stability risk. However, long-term stability should also be considered in terms of the additional expense and damage a fallen tree may cause in the future.

Figure 5-14 is a rendering of what the subject may look like after a couple of years should the multi-stage channel with the bankfull bench be constructed along the entire reach. Once again, this may

represent the “worst case” as some segments of the bank may be sufficiently stable to remain as they are. This will have to be determined after a detailed survey has been performed.



Figure 5-14. Rendering of Channel with Bankfull Bench

5.8 Cost Estimate

Performing stream restoration in confined, urban settings is costly and typically includes fees for the following activities:

- Restoration Design
- Permitting/Approval (City of Fairfax, U.S. Army Corp of Engineers, VA Department of Environmental Quality)
- Construction
- Monitoring and Maintenance

Costs can vary from project to project with the ease of access, the amount of rock required, the degree of required public outreach, and to some extent the amount of work stream restoration contractors have available. With these factors in mind, a rough range of expected costs to restore approximately 750 lf of Daniels Run on the school property is \$400-\$600/lf. This equates to \$300,000 to \$450,000/lf and would result in a permanent restoration of the subject reach.

6 Conclusions and Limitations

The purpose of this initial feasibility analysis was: (1) to investigate flood risks at both condominium sites and to determine the causes of stream erosion at Daniels Run near the Daniels Run Elementary School; and (2) to identify measures for reducing the flooding and stream erosion in these areas. This analysis is considered the first step in developing flood-risk management plans and measures for addressing stream erosion.

The plan objectives for the Foxcroft Colony Condominiums and the Mosby Woods Condominiums are to identify the flood risks and flood damages, and to evaluate measures for flood protection. To address stream erosion on Daniels Run, the main plan objective was to identify measures to return long-term stability to the degraded stream. A wide variety of management measures were evaluated to address planning objectives. Alternative plans were then developed which comprised of one or more of the management measures. The alternative plans went through an initial screening that used the following criteria: effectiveness, environmental considerations, stakeholder impacts, and cost effectiveness. The initial screening resulted in further evaluation of alternative plan design concepts that may be suitable for each study area.

Three alternative plans are recommended for the Foxcroft Colony Condominiums which vary in cost and risk mitigation. The final recommended plan for the Foxcroft Colony study area is dependent of the funding available to support the project.

Alternative Plan 1 is to flood-proof the buildings with an estimated cost of about \$130,000. There are both advantages and disadvantages to this plan. The main advantage to this plan is the low costs when compared to other alternative plans evaluated for this study area. The main disadvantage is that human intervention is required to set up the flood barriers at the windows and patio doors of units in the floodplain. Since the barriers rely on either a closure gate that must be lifted or planks that must be inserted into permanent sidebars, they are temporary and must be installed prior to a flood event. However, if implemented correctly, this plan will reduce the flood risk to Foxcroft Colony residents located in the floodplain. It should be noted that residents in the floodplain should continue to purchase flood insurance since flood-proofing is not a FEMA-recognized method to remove buildings from the floodplain. Alternative Plan 2 consists of minor localized drainage improvements to increase the conveyance of flow on the Accotink Creek including dredging a portion of the creek and a device backflow prevention device to prevent floodwater from the Accotink Creek floodplain at the Foxcroft Colony community. Rough order of magnitude costs for this alternative are \$726,000. The third option (Alternative Plan 3) is to install a floodwall along Old Pickett Road and a portion of Pickett Road to block floodwaters from entering Foxcroft Colony grounds. A pump station is necessary to remove any interior drainage collected behind the floodwall. If designed to FEMA standards for certification, the flood wall may be eligible for FEMA grant funding support. Estimated costs for the floodwall and pump station are approximately \$3 million. Alternative Plan 3 would provide the highest degree of flood risk reduction, protecting the community from the 100-year flood.

Two alternative plans are recommended for the Mosby Woods Condominiums which vary in cost and risk mitigation. The recommended plan from the two for the Mosby Woods study area is dependent of the funding available to support the project. The first plan is to flood-proof the condominium buildings located within the 100-year floodplain. Flood-proofing costs are estimated to be \$125,000. The same advantages and disadvantages apply to this plan as with flood-proofing the Foxcroft Colony buildings. The main disadvantage is that human intervention is required to set up the flood barriers prior to a flood event. However, if implemented correctly, this plan will reduce the flood risk to Mosby Woods residents located in the floodplain. It should be noted that flood-proofed residents in the floodplain at both Foxcroft Colony and Mosby Woods should continue to purchase flood insurance since flood-proofing is not a FEMA recognized method to remove buildings from the floodplain. Proposed Alternative Plan 2 for Mosby Woods includes installing an earthen levee / berm along the North Fork Accotink Creek between Plantation Parkway and Stafford Drive and includes a pump station to remove drainage behind the levee. Estimated costs for this alternative plan are approximately \$2.7 million. This plan provides a higher level of flood risk reduction compared to flood-proofing the buildings.

For Daniels Run, the recommended plan entails grading the channel banks to achieve larger cross-sections and a small floodplain bench; which would likely result in the most stable, environmentally-beneficial, and aesthetically-pleasing restoration. A rough range of expected costs to restore approximately 750 linear feet (lf) of Daniels Run on the school property is \$400-\$600 per lf. This equates to a ROM cost of \$300,000 to \$450,000 and would result in a permanent restoration of the reach.

This document provides an initial feasibility analysis to address flooding issues at Foxcroft Colony and Mosby Woods and to address stream erosion at Daniels Run. The alternative plans selected are based on the ability to be funded and implemented at each of the study areas. For Foxcroft Colony and Mosby Woods it is recommended that alternative measures that provided higher potential risk reduction (such as a levee or floodwall) be further evaluated for consideration if/when additional funds are available to support a project at that scale.

Appendix A: References

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Map of condominium complex with buildings affected by September 2011 Tropical Storm Lee flood event highlighted.

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Appendix B: Stakeholder Meetings Documentation

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Appendix B1: Foxcroft Colony

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DATE AND TIME: February 7, 2013; 7:00 PM

LOCATION: Onsite Management Office - 9483-A Fairfax Boulevard

ATTENDEES (Fairfax City): Christina Alexander (City); Jennifer Solakian (URS); Laurie Huber (URS)

ATTENDEES (Mosby Woods): Members of the Foxcroft Colony Unit Members Association; TBD (Refer to sign in sheet for additional attendees)

Topics

1) INTRODUCTIONS

Representing the City of Fairfax:

Ms. Christina Alexander
Stormwater Resource Engineer
City of Fairfax
Tel: 703-273-3067
Christina.Alexander@fairfaxva.gov
(Primary point of contact)

Ms. Jennifer Solakian
Consulting Engineer
URS Corporation
Tel: 703-713-6415
Jennifer.Solakian@urs.com

Ms. Laurie Huber
Consulting Outreach Specialist
URS Corporation
Tel: 703-713-6445
Laurie.huber@urs.com

2) PURPOSE

The City of Fairfax has contracted with URS Corporation to assess the conditions that lead to flooding which occur at the Foxcroft Colony Condominiums. The purpose of this meeting is to discuss past flooding issues at Foxcroft Colony Condominiums and to inform the Board of Directors of the Initial Feasibility Study process being undertaken.

3) OBJECTIVES

The intended goals of the meeting are as follows:

- To convey the flooding issues as the City of Fairfax understands them.
- To document a set of concerns identified by residents.
- To share the anticipated sequence of events to address the flooding issues at the condominiums.
- To obtain any relevant information that documents the history of flooding.

4) FUTURE EFFORTS

- Initial Feasibility Analysis and conceptional design of proposed alternative solutions.
- City Council Meeting to review documented issues and proposed alternatives.

5) REVIEW OF FLOODING INFORMATION PROVIDED BY FOXCROFT COLONY BOARD

6) QUESTIONS AND DISCUSSION

Meeting Sign-In Sheet

Discussion of Flooding Issues

Foxcroft Colony Condominiums

DATE AND TIME: February 7, 2013; 7:00 PM

LOCATION: Onsite Management Office - 9483-A Fairfax Boulevard

Attendees

NAME	ORGANIZATION	CONTACT INFORMATION
Crystal Ambers	Legum & Norman (Managing Agent)	(703) 970 8883
Ruth Lum	Foxcroft Board	703-731-6594 571-205-8983
Erich Steinbeck	Foxcroft Board	703 403 8480
Bruce Long	Foxcroft Board	bthomaslong@gmail.com
Joe Assante	Foxcroft Site manager	foxcroftcolony@verizon.net
Kevin Jones	Foxcroft, unit owner	703 571 834 954 solarphile@gmail.com
Louise Huber	URS	703 534 7517
Jennifer Solakian	URS	



MEETING MINUTES

PROJECT: Engineering Services for Flooding and Stream Restoration

MEETING 7 February, 2013

DATE: 7:00 PM

RE: Foxcroft Colony Condominiums, Initial Information Gathering Meeting

MINUTES 11 February, 2013

ISSUE DATE:

BY: Laurie Huber
Laurie.huber@urs.com

LOCATION: Foxcroft Colony Condominiums

ATTENDEES: City: Christina Alexander (absent);
URS: Jennifer Solakian, Laurie Huber;
Foxcroft Colony Condominium Board of Directors: Ruth Gumm, Erich Steinbeck, Bruce Long, Joe Assante (Site Manager), Kevin Jones (former board member); Legum & Norman (Management Agent: Crystal Ambers. See Sign-in Sheet, attached.

Item	Discussion	Action Items	By
1.	General: URS provided a meeting agenda and the eight meeting attendees introduced themselves to the group. Jennifer reviewed the purpose of the meeting and the objectives for the meeting. She also explained the extent of the work that the City has asked URS to do and that it was a first step toward resolution of the flooding issues at the property.	None	N/A
2.	Information Gathering: While URS has or has access to all publicly available information related to the nearby creek and flooding histories, additional details from the Condo Association are needed. Copies of various documentation of past flooding were provided to URS by the Board members. Copies of Insurance policies and insurance claims were provided. Detailed information related to specific units flooded during certain storm events was documented. Additionally, a "fieldtrip" was taken to visually review the areas experiencing flooding.	None	N/A
3.	Timing and Process: Completion of the feasibility assessment is expected by late April or early May. Association Board members expressed an interest in when the work that will improve conditions at the property would begin. While it was understood that this will be a process and that immediate resolution is not likely, the Board members	None	N/A



MEETING MINUTES

Item	Discussion	Action Items	By
	<p>emphasized that conditions are serious and that stress comes with every predicted storm event.</p> <p>The City and URS representatives noted that once the assessment is completed, it would be brought before City Council. Whether or not funds are allocated, and when those funds would be available; and how much funding would be available were all noted as unknowns at this time.</p> <p>Members of the Board expressed an interest in attending the City Council meeting when the URS presentation would be made.</p> <p>It was requested that URS/the City provide the Board with the date and time of this presentation as early as possible so that attendance would be possible for all that were interested in attending.</p>	<p>Provide date when it is determined.</p>	<p>URS/City of Fairfax</p>
4.	<p>Input from Board members on specific conditions at the condominiums:</p> <p>Members used an aerial photograph of the area to point out where damaging waters were coming from and accumulating. It was noted that the flood waters were primarily coming in from the "garden" side of the affected buildings and traveling through the exterior door that leads to a hallway where up to four condominium doors were then exposed to flood waters. Additionally, there is a laundry area associated with the hallway and subject to flooding. A Board member said that in addition to waters coming in via the doors, water was also coming in through the floors and walls.</p> <p>It was noted that the frequency and intensity of flooding seemed to be increasing over time. Members stated that while only a few events had resulted in damage to individual units, the ponding of water on the property was routine and often significant in size and persistence. It was also noted that the water table may be high and/or a spring may exist in the area that is contributing to the problems. A description of past steps taken to raise, excavate and re-stabilize a building with concrete slurry was given by a Board member.</p> <p>The Board members provided a variety of documentation to URS, including drawings of the grounds that indicated which units were affected; photos of conditions after flooding; and copies of insurance claims and submission to the City documenting the flooding in September 2011.</p> <p>Board members also used the aerial photograph and a drawing of the creeks and streams in Fairfax City to point out that their property was surrounded by land at higher elevations. Additionally, they pointed out the various developments that</p>	<p>None</p>	<p>N/A</p>



MEETING MINUTES

Item	Discussion	Action Items	By
	had increased the volume and speed of rainwater coming at them during a storm via Accotink Creek.		
5.	<p>Funding Support:</p> <p>Board members asked if steps taken to protect the units / property against further damage from flooding would result in reduced premiums for their flood insurance. Jennifer, the URS storm water engineer, responded that this is possible, but there are specific conditions that must be met.</p> <p>It was noted that matching funds and grants may be available and that URS was tasked with looking for potential opportunities to utilize available funds for the condominiums storm water management improvements.</p>	None	N/A
6.	<p>Communication:</p> <p>Members of the Board wanted to know when and how they would be informed of progress on this project. Additionally, how they would find out about the presentation to City Council so that they could have adequate time to mobilize any interested residents who would like to attend or speak to Council.</p> <p>It was noted that the Board now had contact information for both the City and URS points of contact and that routine contact was encouraged and would be maintained. URS emphasized that the primary point of contact for this project is the Christina Alexander with the City; however, David Summers is a secondary point of contact as Christina will be on temporary leave with the City scheduled for mid-next month.</p>	Contacts with the City and URS will maintain close contact with Board Members	City of Fairfax URS
7.	<p>Additional Notes:</p> <ul style="list-style-type: none">A Board member noted that a pump station may have failed during the 2008 event, but was not certain of this. The pump failing may have led to increased flooding issues onsite.It was noted that the storm sewer manholes and inlets onsite overflow and cause a significant backup of stormwater trying to leave the site. It is possible that floodwaters travel through the storm drains and flood the site.A Board member noted that the adjacent shopping mall containing a Ruby Tuesday and Staples was going to be redeveloped. This would be an opportunity to reduce the storm water coming off of that property, but she was afraid that it might end up increasing the amount of run-off.	None	N/A



MEETING MINUTES

Item	Discussion	Action Items	By
	<ul style="list-style-type: none">• The use of backflow devices should be investigated as a part of the mix of steps taken to better manage storm water.• Redirecting the flow that accumulates at the intersection of Pickett and Old Pickett road to the wooded area across Pickett makes sense. This could be done by adding the number of culverts in the intersection /area.• Emergency gates to use to block water coming in through the exterior door may help, if it is possible to block these doors (since they would block the exit door for four units. Using the gates on the garden side of units could be expensive since the entries on this side are nine feet wide. However, the Board saw the use of gates as a potential temporary lower-cost immediate solution while waiting for a permanent construction solution.		

Appendix B2: Mosby Woods

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Meeting Agenda
Discussion of Flooding Issues
Mosby Woods Condominiums

DATE AND TIME: February 5, 2013; 7:00 PM

LOCATION: Mosby Woods Onsite Office - 10170 Mosby Woods Drive

ATTENDEES (Fairfax City): Christina Alexander (City); Jennifer Solakian (URS); Laurie Huber (URS)

ATTENDEES (Mosby Woods): Members of the Mosby Woods Board of Directors; Michael Dees (TWC Association Management); TBD (Refer to sign in sheet for additional attendees)

Topics

1) INTRODUCTIONS

Representing the City of Fairfax:

Ms. Christina Alexander
Stormwater Resource Engineer
City of Fairfax
Tel: 703-273-3067
Christina.Alexander@fairfaxva.gov

Ms. Jennifer Solakian
Consulting Engineer
URS Corporation
Tel: 703-713-6415
Jennifer.Solakian@urs.com

Ms. Laurie Huber
Consulting Outreach Specialist
URS Corporation
Tel: 703-713-6445
Laurie.huber@urs.com

2) PURPOSE

The City of Fairfax has contracted with URS Corporation to assess the conditions that lead to flooding which occur at the Mosby Woods Condominiums. The purpose of this meeting is to discuss past flooding issues at Mosby Woods Condominiums and to inform the Board of Directors of the Initial Feasibility Study process being undertaken.

3) OBJECTIVES

The intended goals of the meeting are as follows:

- To convey the flooding issues as the City of Fairfax understands them.
- To document a set of concerns identified by residents.
- To share the anticipated sequence of events to address the flooding issues at the condominiums.
- To obtain any relevant information that documents the history of flooding.

4) FUTURE EFFORTS

- Initial Feasibility Analysis and conceptional design of proposed alternative solutions.
- City Council Meeting to review documented issues and proposed alternatives.

5) REVIEW OF FLOODING INFORMATION PROVIDED BY MOSBY WOODS

6) QUESTIONS AND DISCUSSION

Meeting Sign-In Sheet

Discussion of Flooding Issues

Mosby Woods Condominiums

DATE AND TIME: February 5, 2013; 7:00 PM

LOCATION: Mosby Woods Onsite Office - 10170 Mosby Woods Drive

Attendees

NAME	ORGANIZATION	CONTACT INFORMATION
Michael Dees	TWC Assoc. Management Community Manager.	703-437-8500
Terone Brown	Mosby Woods Board TREAS.	703-539-8685
Patsy Over	Mosby Woods Board Secretary	703-591-0546
Heidi Travis	Mosby Woods Board President	703-371-8423
Laurel Huber	URS Outreach	703 336 3906
Jennifer Solakian	URS Engineer Consultant	703 713 6415
Christina Alexander	City of Fairfax	703-213-3067
Officer Mein	Mosby Woods Board	703-591-4872



MEETING MINUTES

PROJECT: Engineering Services for Flooding and Stream Restoration

MEETING 5 February, 2013

DATE: 7:00 PM

RE: Mosby Woods Condominiums, Initial Information Gathering Meeting

MINUTES 11 February, 2013
ISSUE DATE:

BY: Laurie Huber
Laurie.huber@urs.com

LOCATION: Mosby Woods Condominiums

ATTENDEES: City: Christina Alexander;
URS: Jennifer Solakian, Laurie Huber;
Mosby Woods Condominium Board of Directors: Jerome Brown, Patsy Carr, Heidi Travis, Offilia Meir; TWC Assoc. Management: Michael Dees. See Sign-in Sheet, attached

Item	Discussion	Action Items	By
1.	General: URS provided a meeting agenda and the eight meeting attendees introduced themselves to the group. Jennifer with URS reviewed the purpose of the meeting and the objectives for the meeting. She also explained the extent of the work that the City has asked URS to do and that it was a first step toward resolution of the flooding issues at the property.	None	N/A
2.	Information Gathering: While the City and URS has access to all publicly available information related to the nearby creek and flooding histories, additional details from the Condo Association are needed. In addition to the information gathered during the meeting, documents from the Association's attorney, Patricia Bruce will be forwarded to the City and URS.	Materials from Patricia Bruce will be provided.	Mosby Woods
3.	Timing: URS conducted a field investigation for Mosby Woods during the week of 20 Jan, 2013. Completion of the feasibility assessment is expected by late April or early May. Association Board members expressed an interest in when the work that will improve conditions at the property would begin. While it was understood that this will be a process and that immediate resolution is not likely, the Board members emphasized that conditions are serious and that stress comes with every predicted storm event. The City and URS representatives noted that once the assessment is	None	N/A

MEETING MINUTES

Item	Discussion	Action Items	By
	completed, it would be brought before City Council. Whether or not funds are allocated, and when those funds would be available; and how much funding would be available were all noted as unknowns at this time.		
4.	<p>Input from Board members on specific conditions at the condominiums:</p> <p>One member, who has lived at Mosby Woods for 37 years noted that no flooding issues existed for 30 years and now in the last seven things are repeatedly occurring. Another member stated that conditions were “very serious” in that the deterioration and erosion seemed to be increasing exponentially. Members used an aerial photo graph of the area to point out where damaging waters were coming from, including a wraparound effect in one location. Additionally, a Board member described that the flood waters were not only coming in through a man-door but also through the vent associated with the unit’s furnace. A Board member said that although the pool and pump house had not been flooded to date, that waters had come so close to inundating the pump house that they have had to “pull up the pump” on several occasions to avoid the costly destruction of the pump due to flooding.</p> <p>It was noted that the path of the creek had changed and had become a “horseshoe”. Destruction of land that had previously been enjoyed by the residents was mentioned, including the fact that areas where flower bulbs and trees had been planted as a beautification effort (well within the area where residents could walk and “enjoy nature”) were now gone.</p> <p>The Board members confirmed that the units that have had repeated flooding are: 10148, 10149, 10150 and 10101, 10103, 10105 and 10107.</p> <p>Finally, it was noted by a Board member that hundreds of thousands of dollars had been spent and that although some of that money would be reimbursed by FEMA, they were a bit weary and were looking forward to improvements to the conditions that made them feel so vulnerable.</p>	None	N/A
5.	<p>Jurisdiction:</p> <p>The question was raised as to where the property line ran along the creek side of the condominiums. There was some discussion of the sewer line running along the property line, but this was unconfirmed. It was suggested that the attorney could provide the documentation of the property lines for the condominium. Additionally, the City may have some information that can supplement / support where the condominium property ends and the public space begins.</p>	<p>Materials from Patricia Bruce will be provided.</p> <p>Christina Alexander</p>	<p>Mosby Woods</p> <p>City of Fairfax</p>
6.	<p>Communication:</p> <p>Members of the Board wanted to know when and how they would be informed of progress on this project. Additionally, how they would find out about the presentation to City Council so that they could have adequate time to mobilize any interested residents who would like to</p>	<p>A draft survey will be developed.</p> <p>Distribution and collection of</p>	<p>URS</p> <p>Mosby Woods</p>



MEETING MINUTES

Item	Discussion	Action Items	By
	<p>attend or speak to Council. Additionally, it was agreed that input from the residents of all seven units that have been flooded would be sought.</p> <p>It was noted that the Board now had contact information for both the City and URS points of contact and that routine contact was encouraged and would be maintained.</p> <p>Not wanting to limit ideas to just the impacted unit residents, it was suggested that a short survey be developed for the Board to distribute and collect from residents. The responses would then be shared with the City and URS.</p>	<p>surveys will be followed by reporting results to the City and URS contacts.</p>	
7.	<p>Additional Notes:</p> <ul style="list-style-type: none">• A Board member noted that they have all learned that a long slow rain is much preferred to a shorter more intense storm.• A berm of some sort seems to be one way to approach the situation. However, we would like to preserve the access to nature that we have now.• We need to straighten the horseshoe.• Some adjustment to the topography is needed.• Emergency gates to use to block water coming in through the outside or man-door would have limited effect.• We want to encourage pride in ownership here and not allow the continued deterioration of the grounds and units from flooding.• We have taken steps to address the problem from on site, investing heavily in repairs and improvements to stormwater drainage throughout the condominium complex.	<p>None</p>	<p>N/A</p>

Appendix B3: Daniels Run

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Meeting Agenda

Discussion of Erosion Issues

Daniel's Run

DATE AND TIME: February 26, 2013; 10:00 AM

LOCATION: Daniel's Run Elementary School

ATTENDEES (Fairfax City): Christina Alexander (City); Frank Graziano (WSSI); Kelly Petrey (WSSI); Laurie Huber (URS)

ATTENDEES (Daniel's Run Elementary School): Adam Erbrecht (Principal); Lori Huberman Hayes (Science Resource Teacher); TBD (Refer to sign in sheet for additional attendees)

Topics

1) INTRODUCTIONS

Representing the City of Fairfax:

Ms. Christina Alexander
Stormwater Resource Engineer
City of Fairfax
Tel: 703-273-3067
Christina.Alexander@fairfaxva.gov

Mr. Frank Graziano
Consulting Engineer
Wetland Studies and Solutions, Inc.
Tel: 703-679-5651
fgraziano@wetlandstudies.com

Ms. Kelly Petrey
Consulting Engineer
Wetland Studies and Solutions, Inc.
Tel: 703-679-5658
kpetrey@wetlandstudies.com

Ms. Laurie Huber
Consulting Outreach Specialist
URS Corporation
Tel: 703-713-6445
Laurie.huber@urs.com

2) PURPOSE

The City of Fairfax has contracted with URS Corporation and Wetland Studies and Solutions, Inc. (WSSI) to assess the erosion issues in Daniel's Run and to develop potential alternatives to restore/stabilize the channel.

3) OBJECTIVES

The intended goals of the meeting are as follows:

- To learn about the history of the stream erosion in Daniel's Run.
- To discuss the causes of the ongoing erosion.
- To discuss potential restoration options and the associated impacts to adjacent streamside areas.

4) FUTURE EFFORTS

- Initial Feasibility Analysis and conceptual design of proposed alternative solutions.
- City Council Meeting to review documented issues and proposed alternatives.

5) QUESTIONS AND DISCUSSION

Meeting Sign-In Sheet

Discussion of Erosion Issues

Daniel's Run

DATE AND TIME: February 26, 2013; 10:00 AM

LOCATION: Daniel's Run Elementary School

Attendees

NAME	ORGANIZATION	CONTACT INFORMATION
Lori Huberman Hayes	Daniels Run Staff	Lahubermanha@ fcps.edu
Harleen Richlok	Daniels Run	mlrichlok@ fcps.edu
Laurie Huber	URS	laurie.huber@urs.com
Kelly Petrey	WSSI	kpetrey@wetlandstudies.com
Frank Graziano	WSSI	fgraziano@wetlandstudies.com
Christina Alexander	City of Fairfax	christina.Alexander @fairfaxva.gov



MEETING MINUTES

PROJECT: Feasibility Study for Flooding and Stream Restoration

MEETING 26 February, 2013

DATE: 10:00 AM

RE: Daniels Run Elementary School, Initial Information Gathering Meeting

MINUTES 28 February, 2013
ISSUE DATE:

BY: Laurie Huber
Laurie.huber@urs.com

LOCATION: Daniels Run Elementary School

ATTENDEES: City: Christina Alexander;
URS: Laurie Huber;
WSSI: Frank Graziano, Kelly Petrey
Daniels Run Elementary School: See Sign-in Sheet, attached

Item	Discussion	Action Items	By
1.	<p>General:</p> <p>A meeting agenda was provided to meeting attendees and the six meeting attendees introduced themselves to the group. Frank Graziano with WSSI reviewed the purpose and the objectives of the meeting. He also explained the extent of the work that the City has asked URS and WSSI to do and that it was a first step toward resolution of the erosion issues along the portion of Daniels Run abutting the school grounds. He stated that this was just the first phase to take a look at the issue and to develop some potential conceptual alternatives to stabilize the channel.</p>	None	N/A
2.	<p>Information Gathering:</p> <p>While URS and WSSI have access to all publicly available information related to the nearby creek and flooding histories, and the length of Daniels Run in the vicinity of the school has been walked and photographed by WSSI, details from the school staff are needed. Histories of various efforts taken by the school were provided during the meeting by Lori Huberman Hayes, the science resource teacher and board member of Lands and Waters (see below).</p>	None	N/A
3.	<p>Timing and Process:</p> <p>Completion of the feasibility assessment is expected by late April or early May.</p>	None	N/A



MEETING MINUTES

Item	Discussion	Action Items	By
	<p>Christina Alexander noted that once the assessment is completed, it would be brought before City Council. The amount of funds and how they are allocated, and when those funds would be available, were all noted as unknowns at this time.</p> <p>It was requested that URS/the City provide the school staff with the date and time of this presentation as early as possible to allow for maximum attendance of interested staff.</p>	<p>Provide date when it is determined.</p>	<p>City of Fairfax/URS</p>
4.	<p>Input from school staff on specific conditions at the school:</p> <p>Lori Huberman Hayes, a science teacher at Daniels Run for 13 years, shared her involvement with various efforts to stabilize and improve conditions along Daniels Run adjacent to the school property. She expressed what a great teaching tool the issue had been and explained both an excavation of trenches, filled with compost and good soil and the planting of trees, as one project that would both soak up some water that would otherwise go to the stream and the intent to improve the stability of the stream banks with additional plantings. She also expressed concern about this area not being impacted as part of the stream restoration. Another project included the use of Filtrex "socks" installed along the eroding sides of the stream approximately 5-7 years ago.</p> <p>It was noted that while these steps had been successful in the short term, vegetation was never really established and many of the "socks" have been washed away. There was recognition that these steps were not sufficient to stop the continued erosion along the banks of Daniels Run.</p> <p>An aerial photo of the area was used during the conversation to review conditions.</p>	<p>None</p>	<p>N/A</p>
5.	<p>Additional Notes:</p> <ul style="list-style-type: none">Two groups were mentioned as having interest in this project, Lands and Waters (who were instrumental in the Filtrex remediation) and Friends of Daniels Run Park. It was noted that Friends of Daniels Run Park would have a strong interest in proposals that included taking out any trees.It was stated by Laurie Huberman Hayes that erosion became worse after construction of the Farrcroft development that was built in the early 2000's. It was felt that the SWM facility built in Daniel's Run as part of this development did not have a beneficial impact on the condition of the channel and may have made it worse. A maintenance issue with the facility, notably the	<p>None</p>	<p>N/A</p>



MEETING MINUTES

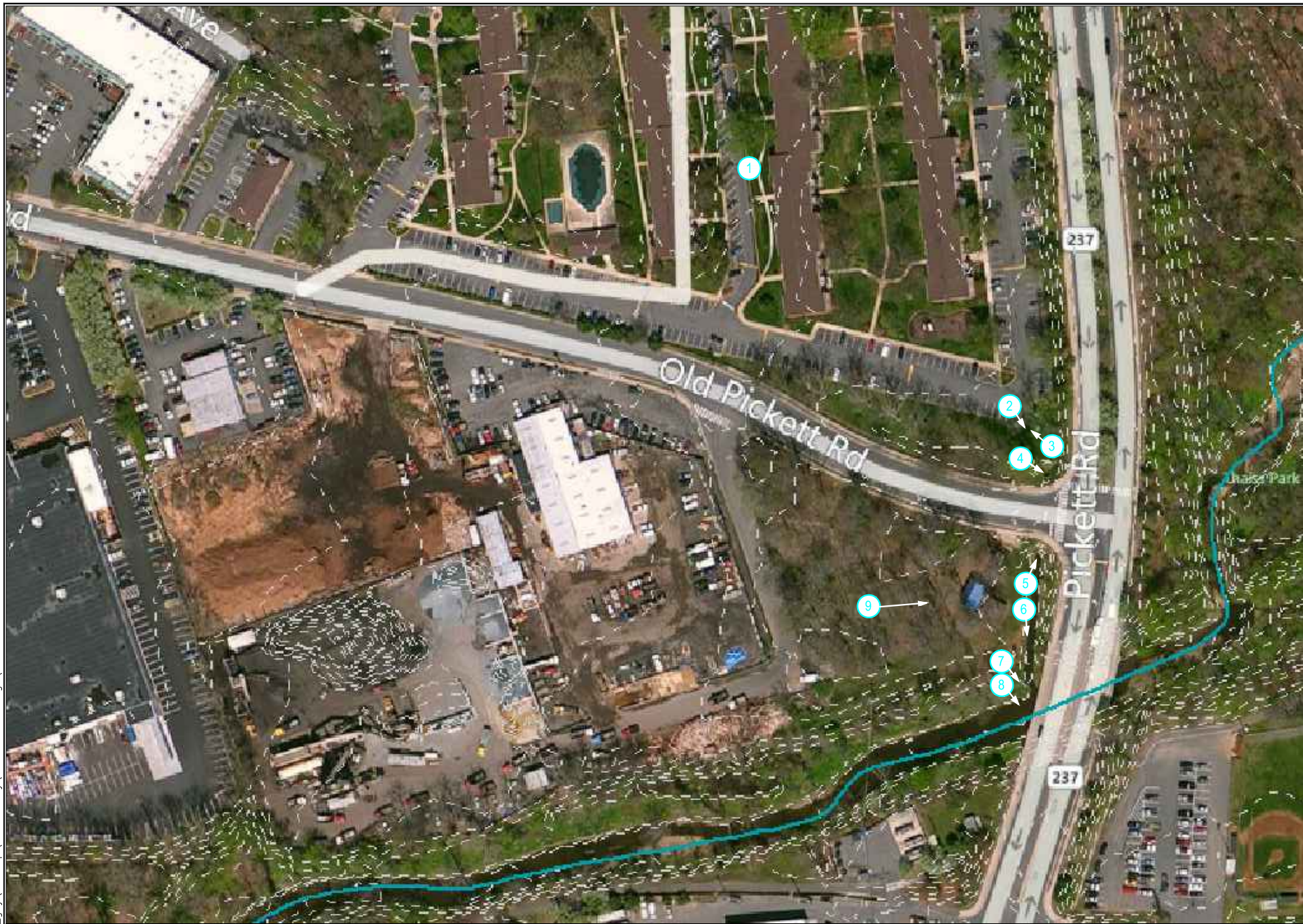
Item	Discussion	Action Items	By
	<p>need to dredge out the sediment forebay, was mentioned by Christina Alexander.</p> <ul style="list-style-type: none">• The close proximity of a house behind the existing church properties was noted as being within the 100-yr floodplain. It was also noted that the church is for sale.• WSSI provided several handouts containing photos of other similar conditions within Fairfax County (Reston) that had been successfully restored to return long-term stability to the degraded urban channels and to return a healthy riparian corridor with diverse, native vegetation.• Ownership of the affected parcels was discussed, with the School owning land on the school side of the stream and the City Parks and Recreation Department owning the other side with the athletic field. This may impact the ultimate design of a restored channel, but for this conceptual phase it will simply be noted in the report.		

Appendix C: Field Notes and Pictures

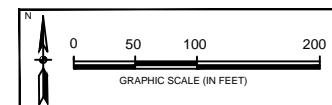
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Appendix C1: Foxcroft Colony

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Foxcroft Colony Condominiums
Photo Locations



Foxcroft Colony Condominiums

Photo 1

Date of Field Reconnaissance:

January 23, 2013

Description:

The condo's windows are often located near ground level.



Photo 2

Date of Field Reconnaissance:

January 23, 2013

Description:

Storm inlet from the Foxcroft Colony Condominiums which leads to the culvert under Old Pickett Road.



Foxcroft Colony Condominiums

Photo 3

Date of Field Reconnaissance:

January 23, 2013

Description:

Photo of
condominiums
taken from the
intersection of
Pickett Road and
Old Pickett Road.



Photo 4

Date of Field Reconnaissance:

January 23, 2013

Description:

Culvert from the
Foxcroft Colony
Condominiums
under Old Pickett
Road (view from the
other side of the
street). Note,
cattails suggest
frequent standing
water.



Foxcroft Colony Condominiums

Photo 5

Date of Field Reconnaissance:

January 23, 2013

Description:

Culvert from the
Foxcroft Colony
Condominiums
under Old Pickett
Road.



Photo 6

Date of Field Reconnaissance:

January 23, 2013

Description:

Runoff from the
Foxcroft Colony
Condominiums to
the Accotink Creek.



Foxcroft Colony Condominiums

Photo 7

**Date of Field
Reconnaissance:**

January 23, 2013

Description:

Culvert under
Pickett Road.



Photo 8

**Date of Field
Reconnaissance:**

January 23, 2013

Description:

Culvert under
Pickett Road.



Foxcroft Colony Condominiums

Photo 9

Date of Field Reconnaissance:

January 23, 2013

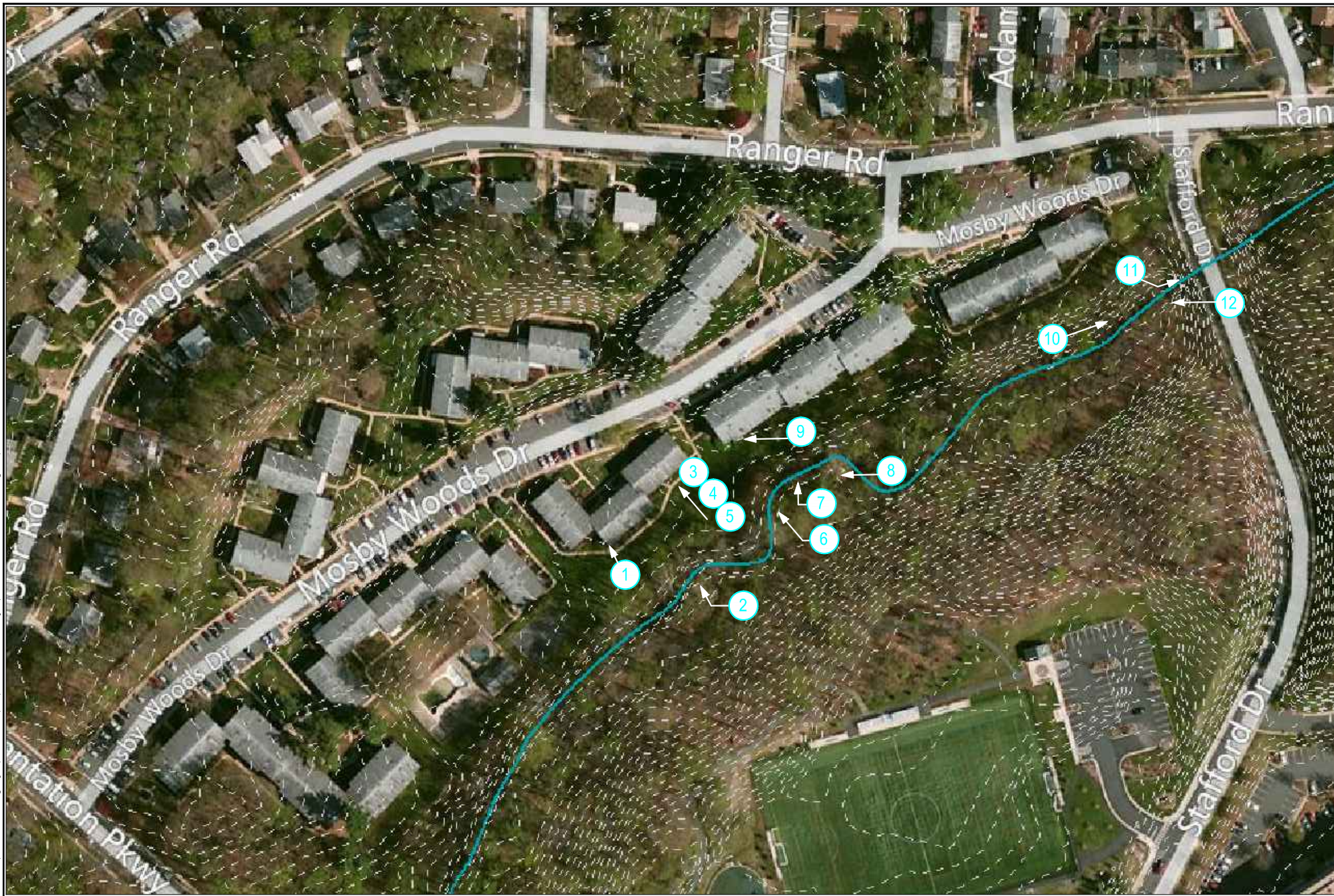
Description:

Structure at
Gateway Regional
Park at the
intersection of
Pickett Road and
Old Pickett Road.

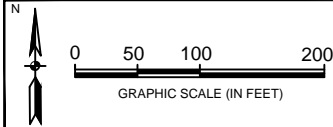


Appendix C2: Mosby Woods

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Mosby Woods Condominiums
Photo Locations



Mosby Woods Condominiums

Photo 1

Date of Field Reconnaissance:

January 23, 2013

Description:

Close-up of windows and doors of condo 10111, one of the condos impacted by flooding.



Photo 2

Date of Field Reconnaissance:

January 23, 2013

Description:

Felled tree on the riverbank near the area impacted by inundation.



Mosby Woods Condominiums

Photo 3

Date of Field Reconnaissance:

January 23, 2013

Description:

Close-up of windows and doors of condo 10103, one of the condos impacted by flooding.



Photo 4

Date of Field Reconnaissance:

January 23, 2013

Description:

Close-up of windows and doors of condo 10103, one of the condos impacted by flooding.



Mosby Woods Condominiums

Photo 5

Date of Field Reconnaissance:

January 23, 2013

Description:

Condominiums which have experienced flood waters. Condos 10105 and 10103 are shown.



Photo 6

Date of Field Reconnaissance:

January 23, 2013

Description:

According to a resident, this tree was planted at a distance to the river. The tree is now practically in the river due to changes in the riverbank over time.



Mosby Woods Condominiums

Photo 7

**Date of Field
Reconnaissance:**

January 23, 2013

Description:

Sand placed by residents at the edge of the riverbank near the area impacted by flooding.



Photo 8

**Date of Field
Reconnaissance:**

January 23, 2013

Description:

Bend in the Accotink near the area experience flooding issues. According to a resident, in the past the river was not as close to the buildings but has changed course over time.



Mosby Woods Condominiums

Photo 9

Date of Field Reconnaissance:

January 23, 2013

Description:

Condominiums which have experienced flood waters. Condos 10105, 10103, 10029, and 10027 are shown.



Photo 10

Date of Field Reconnaissance:

January 23, 2013

Description:

View of Accotink Creek from the Mosby Woods Condominiums facing Stafford Drive.



Mosby Woods Condominiums

Photo 11

Date of Field Reconnaissance:

January 23, 2013

Description:

Culvert located
downstream of the
Mosby Woods
Condominiums at
Stafford Drive.



Photo 12

Date of Field Reconnaissance:

January 23, 2013

Description:

Accotink Creek and
Mosby Woods
Condominiums as
seen from Stafford
Drive.



Appendix C3: Daniels Run

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Design	Draft	Approved	V Datum: NGVD 29	Daniel's Run Elementary School Conceptual Stream Restoration Plan City of Fairfax	
FRG	FRG	FRG	H Datum: NAD 88		
Sheet # 1 of 1			Boundary/Topo Source: City of Fairfax GIS City of Fairfax GIS		
			Scale: 1" = 150'		
File Name: 22234.01 Concept Base.dwg			Date: March 2013	Copyright © 2013 Wetland Studies and Solutions, Inc.	

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



1. Looking upstream toward the Farrcroft SWM Facility. Channel is deeply incised with eroding banks.



2. Looking downstream toward the structure located in the floodplain. Collapsed concrete channel section evident on left bank.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



3. Eroded right bank – note layer of larger sediment.



4. Looking downstream toward the school property line. Fence posts have been exposed where Filtrexx® restoration has washed away.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



5. Vertical right bank with failing Filtrex® restoration.



6. Looking upstream adjacent to the school's infiltration area project.
Filtrex® restoration is failing.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



7. Vertical bank threatening fence adjacent to the play area across from the school. Filtrex® restoration has failed.



8. Vertical bank under the bridge abutment.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



9. Looking upstream along trail adjacent to the play area across from the school.



10. Vertical bank threatening fence line on school property.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



11. Looking downstream. Confined channel with eroding banks and tree loss.



12. Looking upstream along the trail on the schools side of the stream.

Photo Log
Daniels Run Conceptual Stream Restoration
WSSI #22234.01
February 21, 2013



13. Looking downstream just below the school property line. A large tree has recently fallen.

Appendix D: Environmental Considerations

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FEMA Conditional Letter of Map Revision

If a proposed project would, upon construction, affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway and effective 100-year water surface elevations, a Conditional Letter of Map Revision (CLOMR) is required to be submitted for Federal Emergency Management Agency (FEMA) review, per 44 CFR Part 60, 65 and 72. For a community participating in the National Flood Insurance Program (NFIP) such as the City of Fairfax, FEMA requires a submission of a CLOMR for any project that may modify the floodplain or base water surface elevations from the effective FEMA Study. A floodway is not defined in the FEMA FIS however, if any of the proposed alternative plans proposed at Foxcroft Colony or Mosby Woods increases the 100-year water surface elevations a CLOMR may be required for increases in the 100-year floodplain elevation greater than 1.0' due to a proposed project.

Once a CLOMR application is submitted FEMA's comments on whether a proposed project, if built as proposed, would justify a Flood Insurance Study (FIS) and Digital Flood Insurance Rate Map (DFIRM) revision. FEMA's comments are issued in the form of a CLOMR. The CLOMR does not revise an effective NFIP map. It indicates whether the project, if built as proposed, would be recognized by FEMA. Once a project has been completed, a Letter of Map Revision (LOMR) needs to be sent to FEMA to reflect the project. "As-built" certification and other data must be submitted to support the revision request so that NFIP maps can be revised as appropriate. This will allow risk premium rates and floodplain management requirements to be based on current data.

Section 401/404 Wetlands Permits

Two permits are generally required for work that impacts wetlands, a Section 404 permit and a Section 401 permit. "404" refers to Section 404 of the Clean Water Act and likewise, "401" refers to Section 401 of the Clean Water Act. USACE administers Section 404 permits, which are required for the discharge of fill material into streams, wetlands and open waters. In Virginia, the DEQ's Office of Wetland and Stream Protection (OWSP) administers the Virginia Water Protection Permit (VWPP) program, which serves as Virginia's Section 401 certification program for federal Section 404 permits issued under the authority of the Clean Water Act. Typically, if USACE determines that a 404 Permit is required because the proposed project involves impacts to wetlands or waters, then a 401 permit is also required, known as a joint permit.

Generally, activities requiring a permit include dredging, filling, or discharging any pollutant into or adjacent to surface waters, or otherwise altering the physical, chemical or biological properties of surface waters, excavating in wetlands, or conducting the following activities in a wetland:

- New activities to cause draining that significantly alter or degrade existing wetland acreage or functions
- Filling or dumping
- Permanent flooding or impounding
- New activities that cause significant alteration or degradation of existing wetland acreage or functions.

Examples of activities in surface waters, including wetlands, which require a permit include:

- Excavation
- Drainage that significantly alters or degrades existing wetland acreage or function
- Filling or dumping
- Permanent flooding or impounding
- Activities that cause significant alteration or degradation of existing wetland acreage or functions.

Other activities that alter the physical, chemical, or biological properties of state waters and make them detrimental to the public health, animal or aquatic life, or to the uses of such waters for domestic or industrial consumption, or for recreation or for other uses.

For the alternatives discussed in this study, a VWP General Permit WP1 may be obtained if the project impacts less than half an acre (9 VAC 25-660). All other projects will require an individual VWP Permit.

Virginia General Permit for Discharges of Stormwater from Construction Activities

Virginia is in the process of amending and reissuing the General Permit for Discharges of Stormwater from Construction Activities. In August 2012, a draft version of the new permit language was released, available at: http://www.dcr.virginia.gov/laws_and_regulations/lr4.shtml

The guidance presented herein is consistent with the latest regulations; however, guidance may change when the new permit is finalized. The proposed General VSMP Permit for Discharges of Stormwater from Construction Activities authorizes stormwater discharges from the following types of land-disturbing activities:

Large construction activity – Construction activity including clearing, grading, and excavation that results in a land disturbance equal to or greater than five acres. This does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility.

Small construction activity – Construction activity including clearing, grading, and excavation that results in a land disturbance equal to or greater than one acre, and less than five acres. This does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility.

A site-specific SWPPP must be written prior to submitting the registration statement and fee form. After a SWPPP has been prepared, the next step is to apply for permit coverage. A registration statement (Form DCR199-146) and fee form (DCR199-213) must be completed and submitted to DCR along with the appropriate fee payment.

The criteria by which Fairfax City approves, denies, or modifies requests to disturb Chesapeake Bay preservation areas can be found in the city's Chesapeake Bay preservation area ordinance (Sec. 110-76 through 110-92 of the city code). Chesapeake Bay preservation areas are comprised of Resource Protection Areas (RPAs) and Resource Management Areas (RMAs), defined below:

- RPAs include tidal wetlands, non-tidal wetlands, tidal shores, intermittent streams, water bodies with perennial flow, and a 100-foot buffer area on the landward side of any of these components.
- RMAs include all lands in the city that are not designated as RPAs.

The streams discussed in this feasibility study, Accotink Creek, Daniels Run, and the North Fork Accotink Creek, are all considered water bodies with perennial flow. Therefore, the streams and a 100-foot buffer on either side of the streams are considered RPAs. This footprint expands if wetlands are present. The city provides a Chesapeake Bay preservation area map as a guide to the general location of RPAs within the city; however, a site-specific RPA study must be performed to determine the site-specific boundaries of RPA components (Chesapeake Bay Preservation Area Ordinance, Sec 110-83(a)). Based on the scope of this initial feasibility analysis, a site specific RPA study was not completed for any study area and will be required to move forward to design and construction of any alternative plan.

Tree Removal Permit

A tree removal permit is required by Section 110-252 of the City Code for removal of any tree which is five inches or greater in caliper, measured six inches above ground level, on any lot larger than one-half acre or any such tree located in the common open space of any development without first obtaining a tree removal permit.

Erosion and Sediment Control

Regulated land-disturbing activities must comply with state erosion and sediment control regulations found in 4VAC30-50. In the City of Fairfax, the Department of Public Works is responsible for approving soil erosion and sediment control plans. According to Section 110-339 of the City Code, an erosion and sediment control plan and permit are required prior to commencing land-disturbing activities equal to or greater than 2,500 square feet.

Plans identify all onsite erosion and sediment control measures and policies and must comply with the nineteen "Minimum Standards" as specified in the state erosion and sediment control regulations. Plans must be prepared in accordance the guidelines contained in the current edition of the Virginia Erosion and Sediment Control Handbook

Floodplain Permit

Fairfax, Virginia Code of Ordinances. Part II. Chapter 110 – Zoning. Article II District Development Standards and Regulations Generally. Division 2 – Floodplains.

Development within a floodplain in Fairfax City is not allowed without first obtaining a floodplain permit from the Fairfax City zoning administrator. For the purposes of the City's floodplain ordinances, "development" means any manmade change to improved or unimproved real estate, including, but not

limited to, buildings or other construction, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.

The alternatives discussed in this feasibility study include flood control measures for flood risk reduction, and stream restoration. These projects may be permitted “by right” (i.e., no special use permit is required) according to Sec. 110-58.(1)a. of the Code of Ordinances, provided that a floodplain permit is obtained from the City and the following review criteria are met:

- Minimize grading to the maximum extent possible.
- Minimize the amount of impervious surface to the maximum extent possible.
- Minimize loss of natural vegetation and natural stormwater characteristics.
- Minimize the susceptibility of structures to flood damage.
- Will not negatively affect water quality.
- Not increase the intensity or extent of flooding above or below the property.
- Will not adversely affect the capacity of the floodplain channel or increase erosion.
- Prior to working in the floodplain, all applicable permits are obtained.
- Minimize negative impacts upon wildlife habitat.
- Will base the design on flood elevation as specified in Sec 110-59(9)
- Will not result in more than a one-foot increase in the base (100-year) flood elevation.
- Will not negatively impact drainage.

Chesapeake Bay Preservation

Fairfax, Virginia Code of Ordinances. Part II. Chapter 110 – Zoning. Article II District Development Standards and Regulations Generally. Division 3 – Chesapeake Bay Preservation.

The criteria by which Fairfax City approves, denies, or modifies requests to disturb Chesapeake Bay preservation areas can be found in the city’s Chesapeake Bay preservation area ordinance (Sec. 110-76 through 110-92 of the city code). Chesapeake Bay preservation areas are comprised of Resource Protection Areas (RPAs) and Resource Management Areas (RMAs), defined below:

RPAs include tidal wetlands, non-tidal wetlands, tidal shores, intermittent streams, water bodies with perennial flow, and a 100-foot buffer area on the landward side of any of these components.

RMAs include all lands in the city that are not designated as RPAs.

The streams discussed in this feasibility study, Accotink Creek, Daniels Run, and the tributary to Accotink Creek, are all considered water bodies with perennial flow. Therefore, the streams and a 100-foot buffer on either side of the streams are considered RPAs. This footprint expands if wetlands are present. The city provides a Chesapeake Bay preservation area map as a guide to the general location of RPAs within the city; however, a site-specific RPA study must be performed to determine the site-specific boundaries of RPA components (Chesapeake Bay Preservation Area Ordinance, Sec 110-83(a)).

General performance standards for all Chesapeake Bay preservation areas (i.e., both RPAs and RMAs) include:

- Minimize land disturbance.
- Limit disturbing activities to the specified construction footprint.
- Only one construction entrance is allowed.
- Preserve indigenous vegetation.
- Preserve existing trees, however, diseased trees, or trees weakened by age, storm fire or other injury may be removed.
- Limit clearing and grubbing outside the defined limits of disturbance.
- Tree protection barriers will be erected prior to clearing or grading and will remain in place throughout all phases of construction.
- Minimize impervious cover.
- For development and redevelopment, stormwater runoff will be controlled using BMPs consistent with the water quality protection provisions (4 VAC 3-20-71 et seq.) of the Virginia Stormwater Management Regulations that achieve criteria specified in Sec. 110-84(b)(7) of the city's Chesapeake Bay Preservation Area Ordinance.

In addition to the requirements specified above, RPAs have the following additional performance criteria:

- Conform to floodplain regulations, storm drainage facility regulations, erosion and sediment control regulations, and redevelopment criteria.
- Prepare a Water Quality Impact Assessment.
- Retain (or establish, if not present) a 100-foot buffer area of vegetation that is effective in retarding runoff, preventing erosion, and filtering nonpoint source pollution from runoff. Buffer area performance standards can be found in Sec 110-84(d).

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Appendix E: FEMA Grant Program Comparison

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Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Authorities	Section 404 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S. Code (U.S.C.) 5170c.	Section 203 of the Stafford Act, 42 U.S.C. 5133.	Section 1366 of the National Flood Insurance Act of 1968 (NFIA); 42 U.S.C. 4101c, as amended by the National Flood Insurance Reform Act of 1994 (NFIRA), Public Law 103-325; and the Flood Insurance Reform Act of 2004 (FIRA), Public Law 108-264.
Purpose	To significantly reduce or permanently eliminate future risk to lives and property from natural hazards. HMGP funds projects in accordance with priorities identified in State, Tribal, or local hazard mitigation plans, and enables mitigation measures to be implemented during the recovery from a disaster.	To provide funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations.	To reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the National Flood Insurance Program (NFIP).
Program Priorities	Priorities are set by the State under each disaster declaration that includes authorized HMGP assistance.	Provide funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event.	Mitigation activities that reduce or eliminate the long-term risk of flood damage to insured properties.
Applicant Eligibility	State emergency management agencies or a similar State office (i.e., the office that has primary emergency management or as designated by the Governor), the District of Columbia, the U.S. Virgin Islands, American Samoa, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and federally recognized Indian Tribal governments. Each State, Territory, or Tribal government shall designate one agency to serve as the Grantee for the program.	State emergency management agencies or a similar State office (i.e., the office that has primary emergency management or floodplain management responsibility), the District of Columbia, the U.S. Virgin Islands, American Samoa, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and federally recognized Indian Tribal governments. Each State, Territory, or Tribal government shall designate one agency to serve as the Applicant for the program.	State emergency management agencies or a similar State office (i.e., the office that has primary emergency management or floodplain management responsibility), the District of Columbia, the U.S. Virgin Islands, American Samoa, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and federally recognized Indian Tribal governments. Each State, Territory, or Tribal government shall designate one agency to serve as the Applicant for the program.
Subapplicant Eligibility	<ul style="list-style-type: none"> State-level agencies; Federally recognized Indian Tribal governments; Local governments (to include State-recognized Indian Tribes, authorized Indian Tribal organizations, and Alaska Native villages); and 	<ul style="list-style-type: none"> State-level agencies including State institutions (e.g., State hospital or university); Federally recognized Indian Tribal governments; 	<ul style="list-style-type: none"> State-level agencies; Federally recognized Indian Tribal governments; and Local governments (to include State-recognized Indian Tribes, authorized

Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Subapplicant Eligibility	<ul style="list-style-type: none"> Certain private nonprofit (PNP) organizations or institutions. <p>Private individuals or businesses may not apply directly to the State or FEMA, but eligible local governments or PNP organizations may apply to benefit the private entity.</p>	<ul style="list-style-type: none"> Local governments (to include State-recognized Indian Tribes, authorized Indian Tribal organizations, and Alaska Native villages); Public colleges and universities; and Indian Tribal colleges and universities. <p>Private individuals, PNP organizations, and private colleges and universities are not eligible subapplicants; however, an eligible, relevant State agency or local government may apply to the Applicant as the subapplicant for assistance to benefit the private entity.</p>	<p>Indian Tribal organizations, and Alaska Native villages).</p> <p>Private individuals and PNP organizations are not eligible subapplicants. However, an eligible, relevant State agency or local government may apply to the Applicant as the subapplicant for assistance to benefit the private entity.</p>
Eligible Project Grants	<p>Projects to protect either public or private property, as long as the project fits within State and local government mitigation strategies to address areas of risk, and complies with program guidelines. Examples of projects include:</p> <ul style="list-style-type: none"> Acquisition and demolition or relocation of structures, with conversion of the underlying property to deed-restricted open space; Elevation of existing structures to at least the base flood elevation (BFE) or an advisory base flood elevation (ABFE) or higher; Structural and non-structural retrofitting of existing public or private structures; Dry floodproofing of non-residential structures; Minor and localized flood reduction projects; and Construction of safe rooms (tornado and severe wind) for public and private structures. 	<p>Examples of projects include:</p> <ul style="list-style-type: none"> Acquisition and demolition or relocation of structures, with conversion of the underlying property to deed-restricted open space; Elevation of existing structures to at least the BFE or an ABFE or higher; Structural and non-structural retrofitting of existing public or private structures; Construction of safe rooms (tornado and severe wind) for public and private structures; Hydrologic and Hydraulic studies/analyses, engineering studies and drainage studies for the purpose of project design and feasibility determination directly related to the proposed project; Vegetation management for natural dune restoration, wildfire, or snow avalanche; Storm water management projects to 	<p>Examples of projects include:</p> <ul style="list-style-type: none"> Acquisition and demolition or relocation of structures, with conversion of the underlying property to deed-restricted open space; Elevation of existing structures to at least the BFE or an ABFE or higher; Dry floodproofing of non-residential structures; and Minor and localized flood reduction projects. <p>All properties must be NFIP insured at the time of application.</p>

Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Eligible Project Grants		<p>reduce or eliminate long-term risk from flood hazards; and</p> <ul style="list-style-type: none"> Localized flood reduction projects that are designed specifically to protect critical facilities and that do not constitute a section of a larger flood control system. 	
Eligible Planning Grants	<p>Planning grants are available for developing State, local, or Tribal mitigation plans.</p> <p>Funding is available for up to 7 percent of total HMGP grant amount.</p>	<p>Planning grants are available for:</p> <ul style="list-style-type: none"> New plan development Plan updates 	<p>Planning grants are available for planning activities that support the flood hazard component of a State, Indian Tribal, or local mitigation plan that meets the planning criteria outlined in 44 Code of Federal Regulations (CFR) Part 201.</p>
Eligible Management Costs	<p>Administrative costs, management costs, and indirect costs are included in a single Management Cost rate. The amount of Management Cost available to the Grantee is based on a flat rate of 4.89 percent of the projected Federal funding for HMGP. Grantees determine the percentage or amount to pass through to subgrantees.</p>	<p>Management costs are available to support the planning and project subapplications:</p> <ul style="list-style-type: none"> Applicants/Grantees up to 10 percent of total funds requested; and Subapplicants/subgrantees up to 5 percent of total funds requested. 	<p>Management costs are available to support the planning and project subapplications:</p> <ul style="list-style-type: none"> Applicants/Grantees up to 10 percent of total funds requested; and Subapplicants/subgrantees up to 5 percent of total funds requested.
Planning Requirements	<p>All States/Tribes/Territories must have a FEMA-approved and adopted State/Tribal Standard or Enhanced Mitigation Plan to receive HMGP funds. In addition, all subapplicants must have a FEMA-approved local mitigation plan in accordance with 44 CFR Parts 201.6 and 206.434(b) to be eligible to receive project grant funding under the HMGP. All activities submitted for consideration must be consistent with the Grantee's State/Tribal standard or enhanced hazard mitigation plan and the subapplicant's Tribal/local/university hazard mitigation plan for the local jurisdiction in which the activity is located.</p>	<p>All Applicants must have a FEMA-approved State Mitigation Plan (Standard or Enhanced) or Tribal Mitigation Plan by the application deadline to be eligible to apply for project grant funding under the PDM program in accordance with 44 CFR Part 201. In addition, all subapplicants must have a FEMA-approved mitigation plan by the application deadline to be eligible to apply for project grant funding under the PDM program.</p> <p>Projects submitted for consideration must be consistent with the goals and objectives identified in the current FEMA-approved State/Tribal Mitigation Plan and the Tribal/local/university</p>	<p>All Applicants must have a FEMA-approved State Mitigation Plan (Standard or Enhanced) or Tribal Mitigation Plan by the application deadline to be eligible to receive project grant funding under the FMA program, in accordance with 44 CFR Part 201. In addition, all subapplicants must have a FEMA-approved mitigation plan by the application deadline to be eligible to receive project grant funding under the FMA program.</p> <p>In order to be eligible for an increased Federal cost share of up to 90 percent for severe repetitive loss properties, the FEMA-approved State or Tribal Standard Mitigation Plan in effect at the time of grant award must address repetitive loss</p>

Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Planning Requirements		mitigation plan for the jurisdiction in which the activity is located. If any plan is due to lapse soon after application, the project award may be held pending approval of a new or updated plan.	properties. If any plan is due to lapse soon after application, the project award may be held pending approval of a new or updated plan.
Application Process	The primary responsibility for selecting and administering mitigation activities resides with the State. The State sets mitigation priorities and selects project subapplications that are developed and submitted by local jurisdictions. Although individuals may not apply directly to the State for assistance, local governments may sponsor an application on their behalf. After its eligibility review, the State forwards subapplications consistent with State mitigation planning objectives to FEMA for review and approval.	Applicants must apply electronically via FEMA's eGrants application, available at https://portal.fema.gov . Subapplicants apply directly to the Applicant, who reviews and prioritizes the subapplications. The Applicant submits the Grant application with subapplications to FEMA for review and approval.	Applicants must apply electronically via FEMA's eGrants application, available at https://portal.fema.gov . Subapplicants apply directly to the Applicant, who reviews and prioritizes the subapplications. The Applicant submits the Grant application with subapplications to FEMA for review and approval.
Available Funds	Federal funding under the HMGP is available following a major disaster declaration, if requested by the Governor. As of October 4, 2006, if a State has a FEMA-approved Standard State Mitigation plan, HMGP funds are available based on up to 15 percent for amounts not more than \$2 billion of the total of Public and Individual Assistance funds authorized for the disaster; up to 10 percent for amounts of \$2 billion to not more than \$10 billion; 7.5 percent for amounts of \$10 billion to not more than \$35.333 billion. If a State has a FEMA-approved Enhanced Mitigation plan, HMGP funds are available based on up to 20 percent of the total of Public and Individual Assistance funds authorized for the disaster.	Pending Appropriation.	Funding comes from NFIP
Cost-Share Requirements	HMGP grant funds may be used to pay up to 75 percent of the eligible project costs. The non-Federal match does not need to be cash; in-kind services or materials may be used.	FEMA may contribute up to 75 percent Federal funding for the amount approved under the grant award to implement approved activities. Small and impoverished communities may be eligible for up to a 90 percent	FEMA may contribute up to 75 percent Federal funding for the amount approved under the grant award to implement approved activities. An increased Federal cost share of up to 90 percent is available for the mitigation

Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Cost-Share Requirements		Federal cost share.	of severe repetitive loss properties for any Applicant that has taken actions to reduce the number of repetitive loss properties, including severe repetitive loss properties, and has a FEMA-approved State or Tribal Mitigation Plan that specifies how it has reduced, and how it intends to reduce, the number of such repetitive loss properties.
Distribution of Funds	The HMGP is administered by the State. The mitigation planning and application development process begins at the local level. States prioritize local subapplications and select projects for funding.	Grants are awarded on a competitive basis. Eligible subapplications will compete nationally for grant funds.	Applicants may receive a FMA project and planning target allocation based on the national percentage of NFIP policies present within the jurisdiction. An Applicant may apply for funding up to or exceeding its target allocation.
Application Deadline	Generally, subapplications must be submitted to the State for consideration within 12 months following a disaster declaration.	Applicants must submit a grant application through the eGrants system to the appropriate FEMA Regional Office by the specified timeframe posted on the FEMA website. All supporting documentation that cannot be attached to the eGrants system must be received by the FEMA Regional Office by the application deadline.	Applicants must submit a grant application through the eGrants system to the appropriate FEMA Regional Office by the specified timeframe posted on the FEMA website. All supporting documentation that cannot be attached to the eGrants system must be received by the FEMA Regional Office by the application deadline.
Application Review	Project subapplications are reviewed by the State to ensure all program requirements are met. States should submit eligible subapplications for funding. There are five minimum criteria that all projects must meet in order to be considered for funding: <ul style="list-style-type: none"> • Conforms with the State Hazard Mitigation Plan; • Provides beneficial impact upon the designated disaster area; 	Project subapplications are reviewed by the Applicant to ensure all program requirements are met. Applicants should submit eligible subapplications for funding. Applications and subapplications are reviewed by FEMA for: <ul style="list-style-type: none"> • Eligibility and completeness; • Cost effectiveness; • Engineering feasibility and 	Project subapplications are reviewed by the Applicant to ensure all program requirements are met. Applicants should submit eligible subapplications for funding. Applications and subapplications are reviewed by FEMA for: <ul style="list-style-type: none"> • Eligibility and completeness; • Cost effectiveness; • Engineering feasibility and

Appendix E: FEMA Grant Program Comparison

Program Element	Hazard Mitigation Grant Program (HMGP)	Pre-Disaster Mitigation (PDM)	Flood Mitigation Assistance (FMA)
Application Review	<ul style="list-style-type: none"> • Conforms with environmental laws and regulations; • Solves a problem independently or constitutes a function portion of a solution; and • Is cost-effective. 	<p>effectiveness; and</p> <ul style="list-style-type: none"> • Environmental/Historic Preservation compliance. <p>National Ranking - FEMA will score all eligible planning and project subapplications on the basis of predetermined, objective, quantitative factors to calculate a National Ranking Score.</p> <p>National Evaluation - National panels chaired by FEMA and composed of representatives from FEMA Headquarters and Regions, other Federal agencies, States, federally-recognized Indian Tribal governments, Territories, and local governments convene to evaluate planning and project subapplications on the basis of additional pre-determined qualitative factors.</p> <p>Technical Review - FEMA conducts technical reviews for Benefit Cost and Engineering Feasibility on the highest scoring project subapplications representing approximately 150 percent of available funding.</p>	<p>effectiveness; and</p> <ul style="list-style-type: none"> • Environmental/Historic Preservation compliance.

Appendix F: Rainfall Support Data for Review of Flooding

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Rainfall data collected at local rain gages were retrieved from the past several years to evaluate and correlate rainfall events and flooding at Foxcroft Colony and Mosby Woods condominiums. Rainfall charts for Hurricane Sandy, Tropical Storm Lee, and Hurricane Hanna and the 2006 unnamed tropical cyclone are shown in **Charts F-1, F-2, F-3 and F-4**, respectively. The start time of the storm event was considered to be when consistent rainfall commenced. The end time was when rainfall ceased.

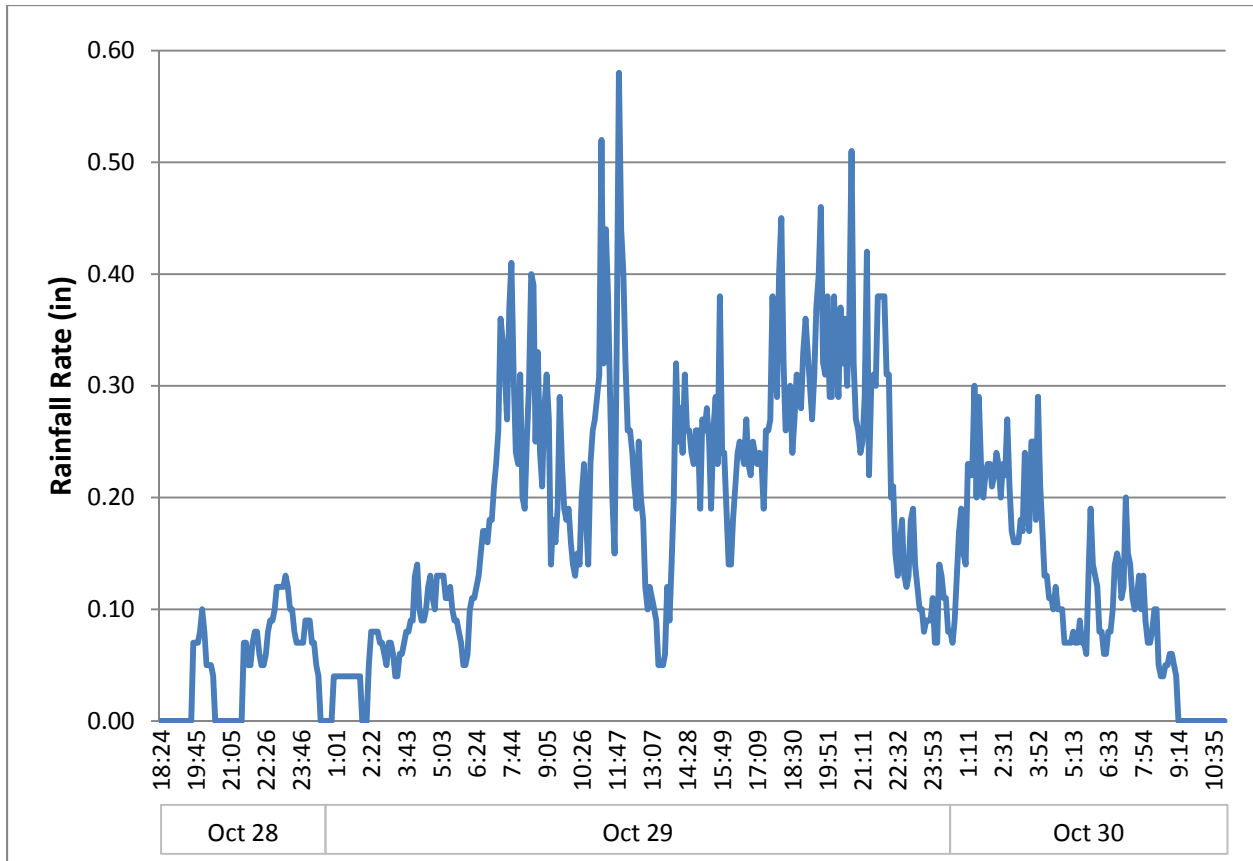


Chart F-1. Hurricane Sandy (2012) Rainfall vs. Time

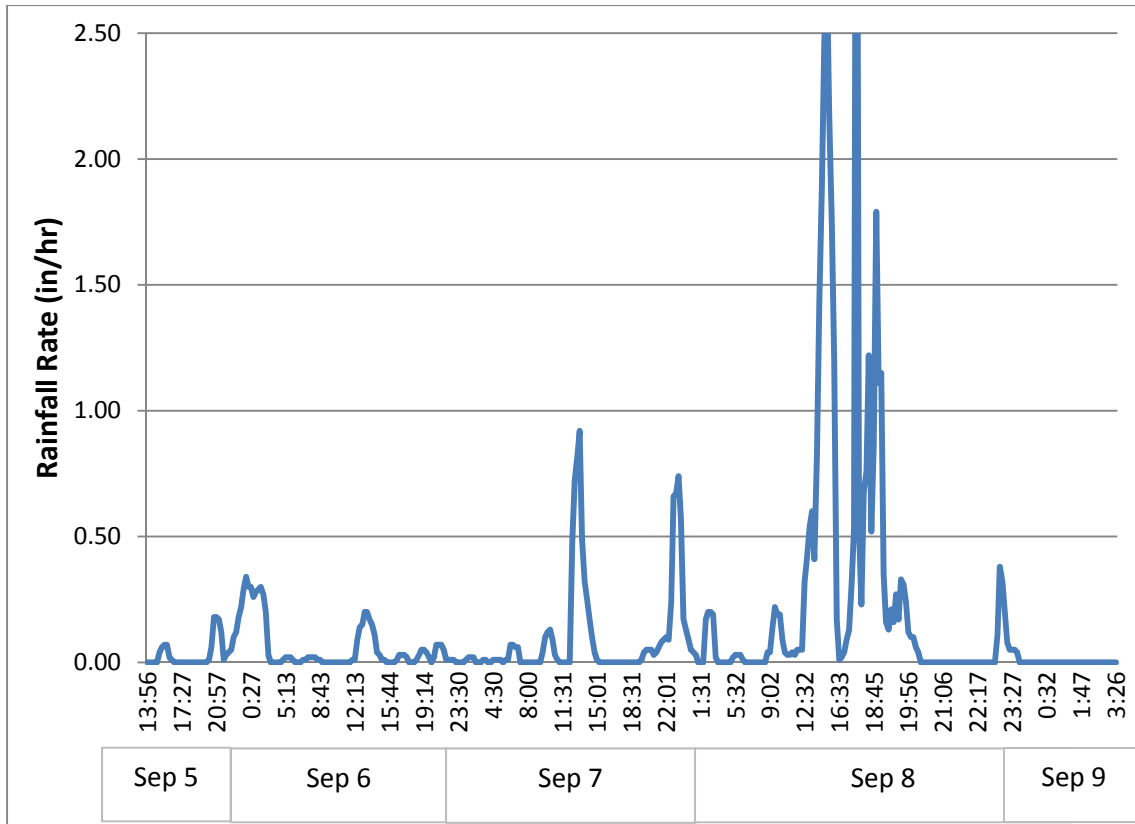


Chart F-2. Tropical Storm Lee (2011) Rainfall vs. Time

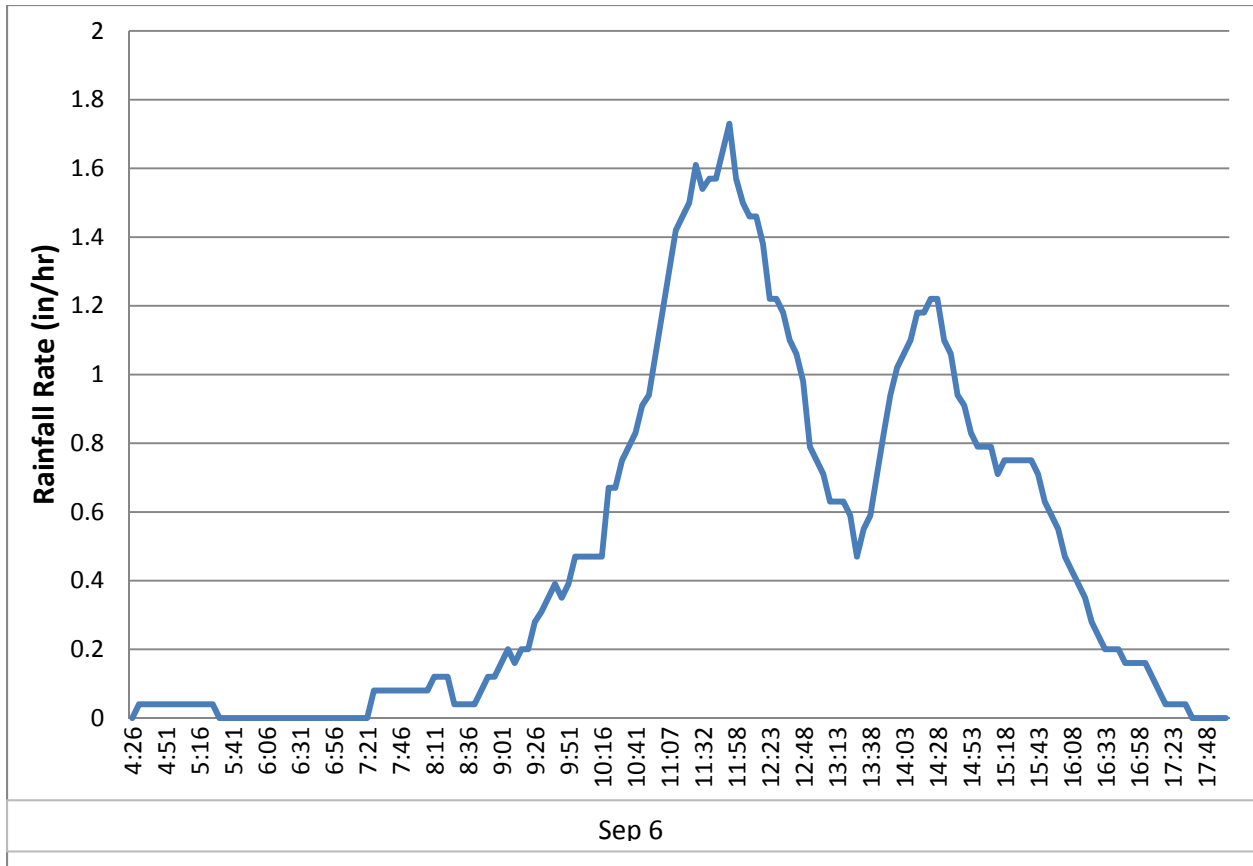


Chart F-3. Hurricane Hanna (2008) Rainfall vs. Time

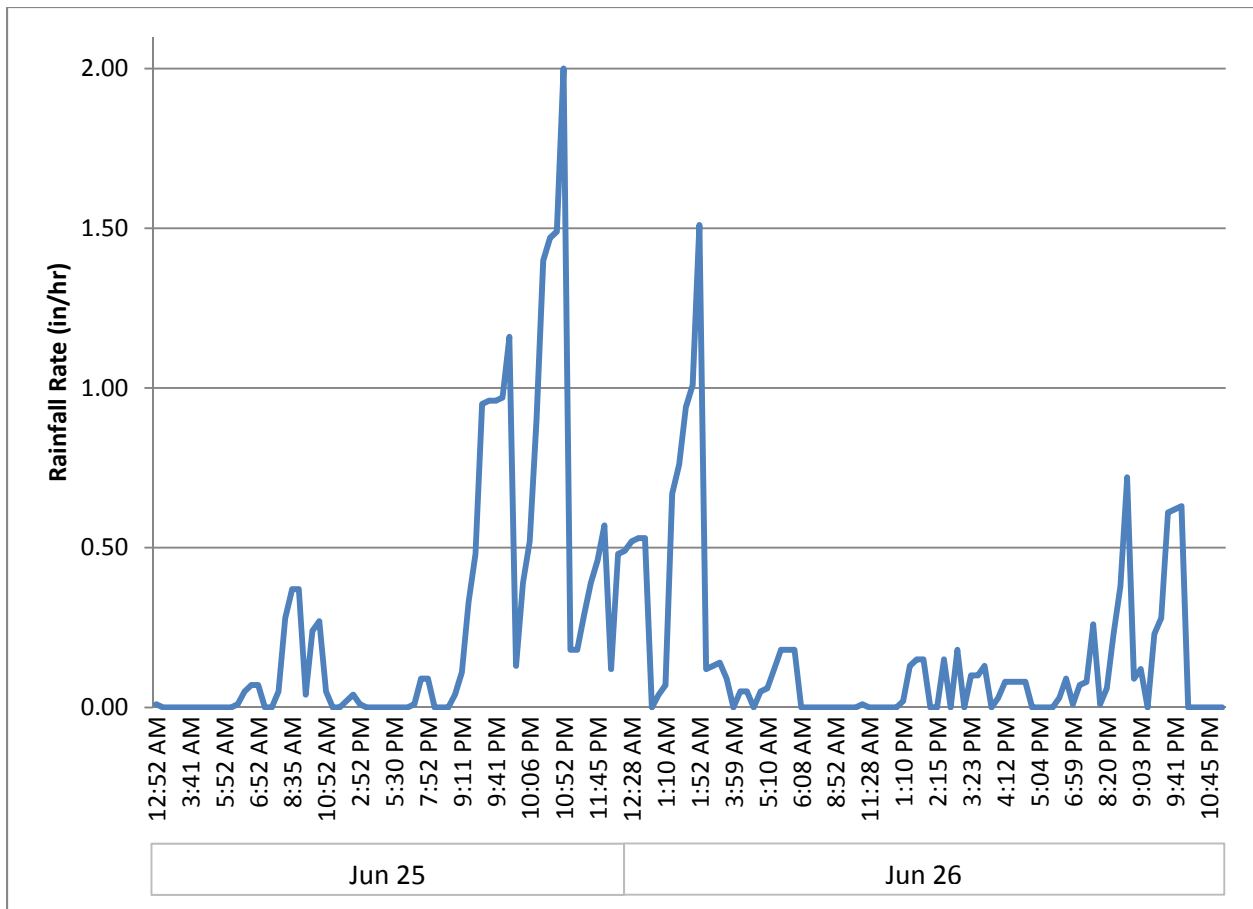


Chart F-4. Unnamed Tropical Cyclone (2006) Rainfall vs. Time